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THE METHODS AND RESULTS

OF

THE SURVEY

OF THE

WEST COAST OF LOWER CALIFORNIA

BY THE

OFFICERS OF THE U. S. S. "RANGER"

DURING THE

SEASON OF 1889 AND 1890.

U. S. Bureau of Navig. - Hydrographic

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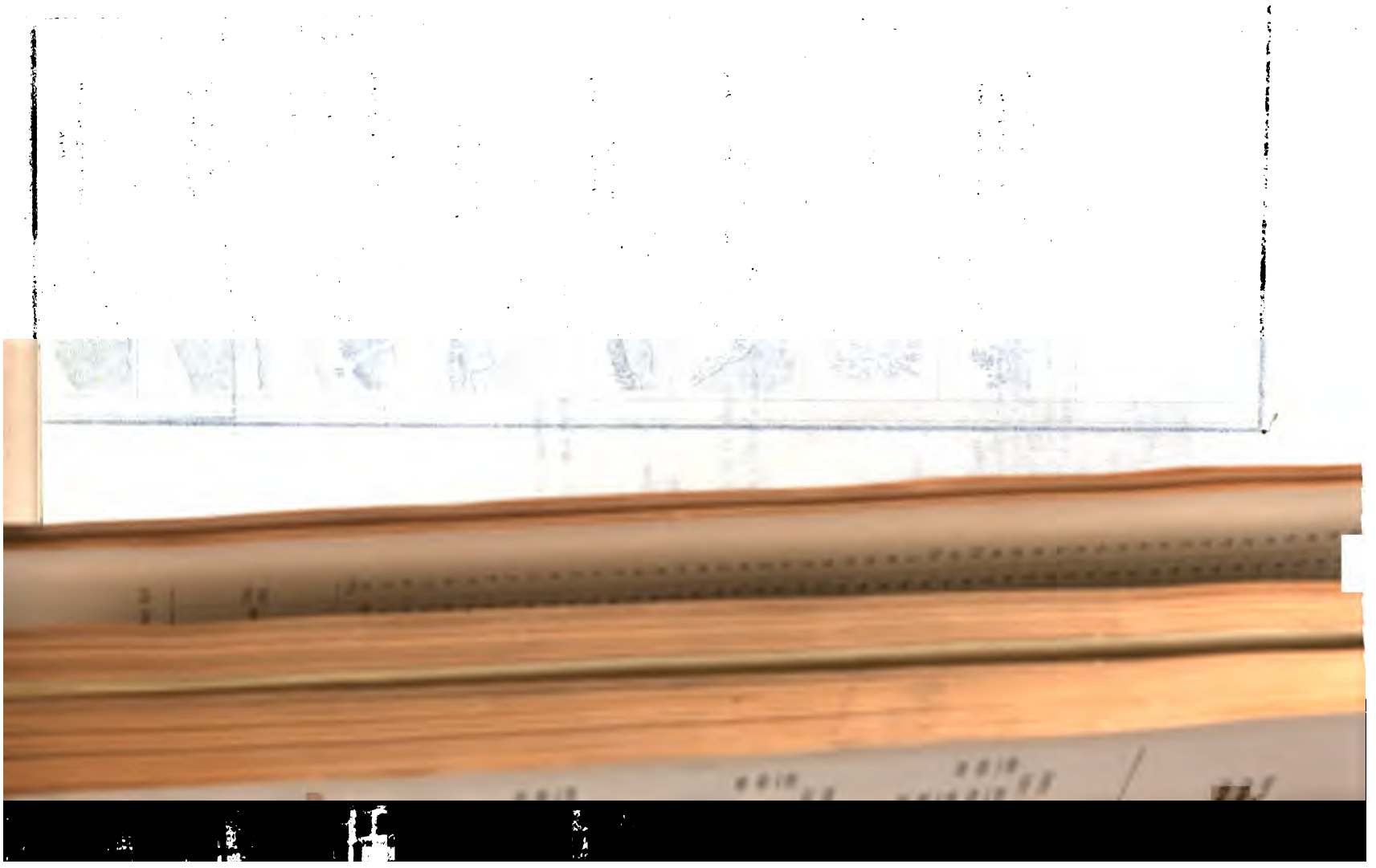

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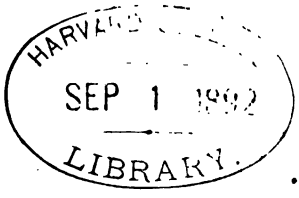


Hydrographic Office

CONTENTS.

	Page.
Preface	5
The operations embraced by the survey	7
The reconnoissance	7
Preliminary movements	8
CHAPTER I.	
The main triangulation	9
The computation of the lengths of the sides of the triangles	12
The computation of the latitudes, longitudes, and azimuths	62
Report of the main triangulator describing difficulties to be overcome	146
CHAPTER II.	
The secondary or shore triangulation	150
CHAPTER III.	
Hydrography	152
Boat signals	152
Boat sheets	155
Laying out the work	157
Steam launches and their crews	157
Instruments and articles needed	159
Running a line of soundings in a boat	160
Fixing the position	161
Ship's work	163
Sextants	166
Protractor	168
Leads and lead lines	169
Ranges	170
Steering	171
Soundings	171
Selection of signals	172
CHAPTER IV.	
The magnetic work	173
The formulæ used in deducing the results	174
The observations made at Asuncion Island	176
The deduction of an empirical equation for predicting values of the declination	205
CHAPTER V.	
The determination of the geographic position of Abreojos Point	208
The chronograph	209
Chronometers	210

Page.
The determination of the geographic position of Abreojos Point—Continued.
The portable observatory 210
The transit pier 210
The method of observing for longitude 210
The deduction of the longitude 213
Observations for latitude 215
The deduction of the latitude 217

CHAPTER VI.

The measurement of the Abreojos Point base line 218
The bearing of the north base from the observation spot 221

CHAPTER VII.

Tidal observations 222
Results of the tidal observations at Asuncion Island 224

CHAPTER VIII.

Constructing the charts 226
Table for the construction of the polyconic projection on a scale of $\frac{1}{126720}$. 226
Computation of the Mercator projection 233
Laying down of the Mercator projection 234
The engraving 236
Printing 237

PREFACE.

This report has been planned and mainly written by G. W. Littlehales, C. E., Chief of the Division of Chart Construction. Its object is to record the methods of conducting a survey for the production of nautical charts which have gradually been developed in the survey of the west coast of Mexico under the direction of the Hydrographic Office, Bureau of Navigation, Navy Department, and, by placing the results of experience in the hands of future workers in the same field, to afford a surer means of securing further advance in this most important branch of nautical science. Chapters I and II were written by Lieut. O. W. Lowry, and Section 9 of Chapter III by Ensign L. S. Van Duzer, U. S. Navy.

The operations described and the results given relate to the work performed during the period from November, 1889, to March, 1890, during which time the survey was under the immediate supervision of Lieut. Commander George C. Reiter, U. S. Navy, commanding the U. S. S. *Ranger*.

Lieut. U. R. Harris, executive officer, was charged with the duty of providing for boat and shore parties and directed the tidal observations and the measurement of the base line. While the ship was at work under way, he was one of three observers who were stationed on deck taking angles to determine the altitudes of peaks and to fix the positions of soundings.

Lieut. C. W. Bartlett, navigator, was the astronomer of the survey. He made the observations for latitude and longitude of the observation spot and for the azimuth of the base line.

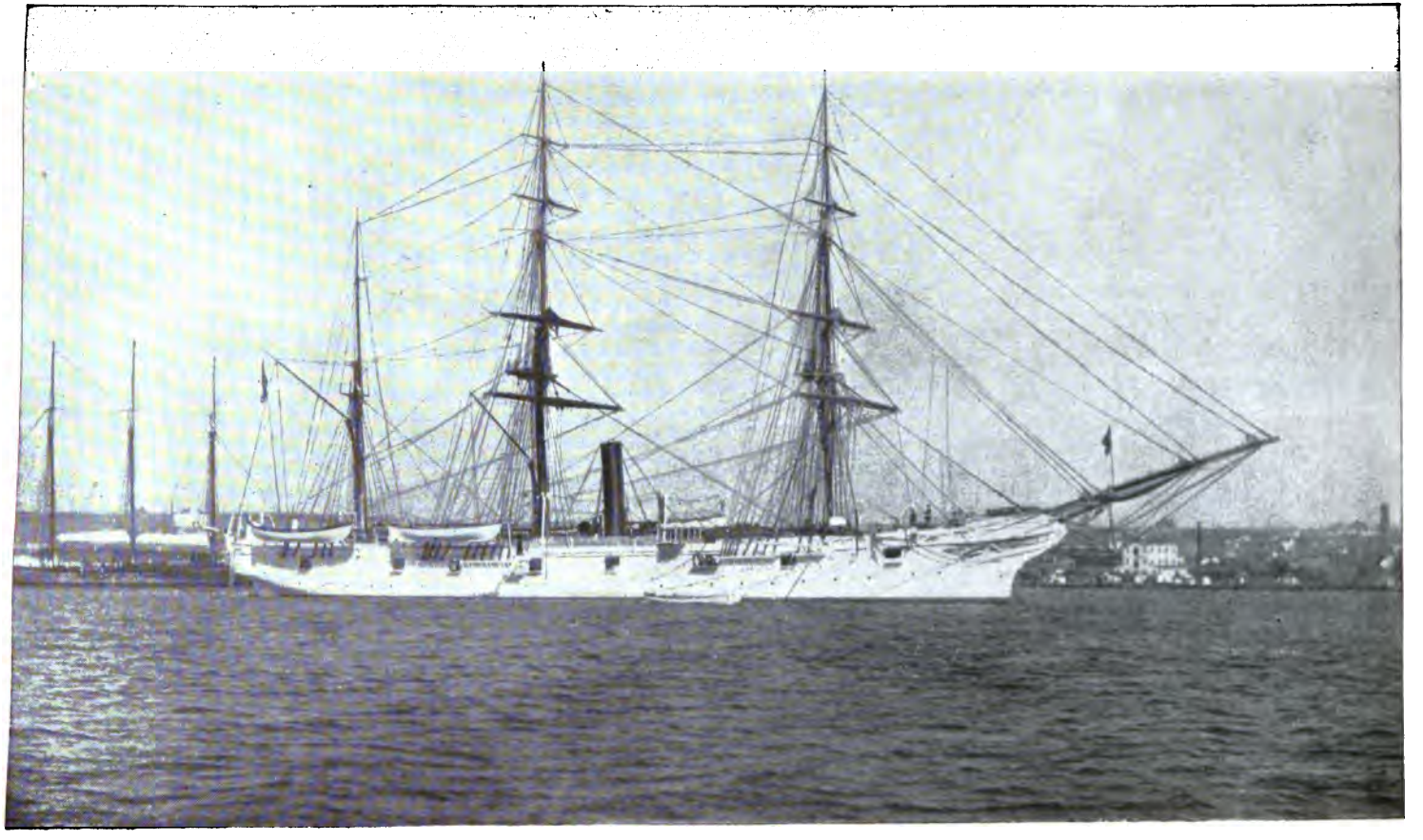
Lieuts. O. W. Lowry and W. F. Halsey performed the main and secondary or shore triangulations, respectively, and made the necessary computations and plotted the work to form the deck-board, boat, and plotting sheets.

Lieut. C. F. Pond had charge of the magnetic work and took the ship's soundings. He was also the photographer of the survey.

Ensigns W. A. Gill and L. J. Clark were assigned exclusively as watch officers. But Lieuts. Lowry, Halsey, and Pond, and Ensigns Knepper, Wright, Burke, and Churchill also performed the duties of watch officers.

Ensigns C. M. Knepper and B. Wright, assisted by Ensigns W. S. Burke and C. Churchill, were engaged in the development of the inshore hydrography in the steam launches.

RICHARDSON CLOVER,
Lieutenant-Commander, U. S. Navy, Hydrographer.



THE U. S. S. RANGER.

THE METHODS AND RESULTS OF THE SURVEY OF THE COAST OF LOWER CALIFORNIA BY THE OFFICERS OF THE U. S. S. RANGER.

THE OPERATIONS.

The survey consisted of a main and a secondary or shore triangulation, in connection with which the coast line and topography were delineated, conducted from accurately measured bases; of the establishment of the geographic positions, by astronomical observations with the portable transit and by the transportation of time by chronometers at selected points in the harbors and anchorages, and, with especial accuracy, at the beginning and end of the season's work; of the observation of the magnetic declination, dip, and intensity at or near the astronomical observation spots; of a system of lines of soundings, normal to the general trend of the coast, run by launches, one-half a mile apart, from the shore to a distance of 3 miles out or further if the 10-fathom line was not then reached, and by the ship, one-half to 1 mile apart, from the outer edge of the launch work to the 100-fathom line, and a series of lines by surf boats filling in the interior launch work, so that the whole water area of the survey was developed by soundings

$\frac{1}{20}$ of a mile apart in depths less than 5 fathoms,
$\frac{1}{10}$ of a mile apart in depths from 5 to 10 fathoms,
$\frac{1}{4}$ of a mile apart in depths from 10 to 20 fathoms,
$\frac{1}{4}$ of a mile apart in depths from 20 to 50 fathoms,
1 mile apart in depths from 50 to 100 fathoms,
3 miles apart in depths from 100 to 300 fathoms, and
5 miles apart in depths over 300 fathoms.

THE RECONNOISSANCE.

Having arrived at the working ground, it was customary, before commencing work, to steam the ship along the coast to be surveyed, keeping as close in as possible without frequent changes of course. The main and secondary triangulators remained on deck taking angles upon peaks already located, to fix those in advance with sufficient accuracy for identification, and plotting and naming them upon the chart of the ship's previous work. About 40 miles of the distance allotted for a season's work was thus gone over, the ship anchoring at night and resuming her way in the morning. In this manner the general distribution of the landmarks was developed upon the ship's rough sheet, and the triangulators were enabled intelligently to select the peaks to be occupied as triangulation stations. Futile trips on shore were thus saved.

After the reconnoissance the ship would return to the initial point, land the main triangulator at a place near that point from which the first group of stations he wished to occupy was most accessible, and land the navigator for astronomical observations and a party to select and measure a base line and erect base signals. The main triangulator, having been informed where to look for the base signals and observation spot, would observe them from his stations and afterwards occupy them and cut on all visible objects of prominence, including the observation spot. He would also determine the azimuth of the base.

The ship meantime remained at anchor and base-line party returned on board each night, the navigator staying on shore for night observations. During this enforced inaction a tide-gauge party was generally at work, and, if a harbor or anchorage were near at hand to be surveyed, the secondary triangulator would triangulate it and the launches sound it out independently of the general work, as it could easily be connected up afterwards.

The main triangulator having returned on board and the base-line and observation-spot parties having completed their labors, the ship would steam down to another point suitable to the main triangulator and again land him. The secondary triangulator would be left behind to work his way along the coast, putting up signals for the launches' work, cutting them in, connecting them by cuts on the main triangulation, and cutting in the shore line. It was held to be of extreme importance that these two triangulators should be fully cognizant of each other's plans, in order that they might observe each other's stations. When these two officers returned it was customary for them to compare notes, plot their work, and prepare ship's and boats' rough sheets. Enough had now been accomplished for sounding to begin, and from this time it was usual to carry on all the branches of the work simultaneously throughout the season.

CHAPTER I.

THE MAIN TRIANGULATION.

The main triangulation was carried along from season to season, starting from and ending with a measured base. At times, owing to the configuration of the country, the absence of suitable places for such measurement, or other circumstances, the second base line had to be measured during the middle of the season and the new scheme of triangulation carried over from one season to another.

The accompanying illustration shows the main triangulation between Cerros Island and Abreojos Point, reduced to one-third the scale upon which it was originally plotted.

The observation spot was located near the base line, both ends being visible from it, and it was connected to the base by main triangulation. The true azimuth of some distant point of the main triangulation was computed from the observation spot, and from this the true azimuths of all the sides of the various triangles were deduced. At each station of the main triangulation the points used for triangulation were "cut" upon from five to ten times, depending upon the atmosphere, with a 6-inch Fauth & Co. repeating theodolite reading to 30″, obtaining readings from the zero station around the entire circle, if the angle was large. The mean of these readings gave the actual observed angle between the previously fixed point and those following, and the repeating process not only gave a finer determination of the angle as read by both verniers, but eliminated the errors of graduation of the instrument. The angles being repeated with the telescope, both direct and reverse, eliminated the error of collimation. The correction for spherical excess in the final adjustment was neglected in all but a very few cases, owing to the comparatively short lengths of the sides of the triangles. The angles thus obtained were used in the computations by using the system of quadrilaterals instead of simple triangles, that system having been shown to produce the most accurate results. It also enables one to determine, without occupation, the position of a far distant point, or one difficult of access, and afterward utilize it as a key point in other contiguous quadrilaterals, while by any other system this distant point could only be "cut in." It is a labor-saving process, without any sacrifice of accuracy.

In any field work a discrepancy is sure to exist in the measurement of angles. The sum of the three measured angles of any triangle seldom equals 180° exactly, and the measured angles of a quadrilateral seldom, if ever, equal exactly 360°. The result is excellent (with angles upon natural objects, such as the highest point of a mountain peak) when the sum of the corners of a quadrilateral do not differ more than two minutes from 360°, and in a triangle are not more than one minute from 180°. The field notes concerning wind and weather—whether misty, hazy, or wavy atmosphere—when judiciously used, are excellent aids in giving weight to the various angles recorded in the field book.

A book for the purpose of facilitating the work of adjustment and computation and preserving it in good form was designed in the Hydrographic Office from drawings by Lieut. O. W. Lowry, U. S. Navy. The measured angles of each quadrilateral are shown in the upper portion, and below them, in their order, are shown the two angles which together form the corner of the quadrilateral. Below these are the angles forming each triangle of the quadrilateral. The sum of the measured angles in each case is given, and columns are provided for entering the adjusted values of the angles. When the finally adjusted values were obtained they were used, according to the formulas for the solution of the plane triangles, in computing the lengths of the sides of the triangles. A résumé of this work is here given.

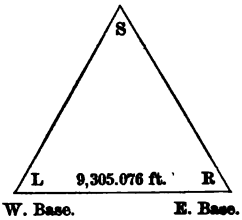
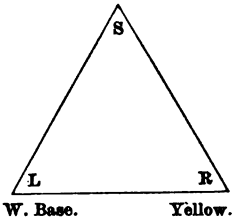
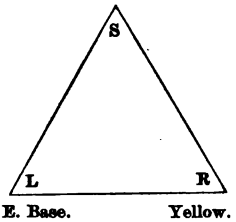
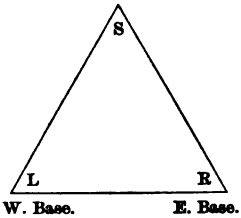
QUADRILATERAL No. 1.

YELLOW, EAST BASE, WEST BASE, OBSERVATION SPOT.

	Measured angles.			1st Adj.		2d Adj.		3d Adj.	
	°	′	″	′	″	′	″	′	″
Yellow, E. Base, W. Base	72	43	35	43	28	43	23	43	25
E. Base, W. Base, Obs. Spot	137	42	23	42	16	42	18	42	20
W. Base, Obs. Spot, Yellow	97	27	00	26	53	26	52	26	54
Obs. Spot, Yellow, E. Base	52	07	30	07	23	07	19	07	21
	360	00	28	00	00	59	52	00	00
Yellow, E. Base, Obs. Spot	61	40	08	39	26	39	09	.....	
Obs. Spot, E. Base, W. Base	11	03	22	03	57	04	16	.....	
	72	43	30	43	23	43	25	.....	
E. Base, W. Base, Yellow	68	57	22	57	18	57	21	.....	
Yellow, W. Base, Obs. Spot	68	45	08	45	00	44	59	.....	
	137	42	30	42	18	42	20	.....	
W. Base, Obs. Spot, E. Base	31	12	30	13	05	13	24	.....	
E. Base, Obs. Spot, Yellow	66	14	30	13	47	13	30	.....	
	97	27	00	26	52	26	54	.....	
Obs. Spot, Yellow, W. Base	13	48	15	48	08	48	07	.....	
W. Base, Yellow, E. Base	38	19	15	19	11	19	14	.....	
	52	07	30	07	19	07	21	.....	
Yellow, E. Base, Obs. Spot	61	40	08	39	26	39	09	.....	
E. Base, Obs. Spot, Yellow	66	14	30	13	47	13	30	.....	
Obs. Spot, Yellow, E. Base	52	07	30	06	47	07	21	.....	
	180	02	08	00	00	00	00	.....	
Obs. Spot, E. Base, W. Base	11	03	22	03	57	04	16	.....	
E. Base, W. Base, Obs. Spot	137	42	23	42	58	42	20	.....	
W. Base, Obs. Spot, E. Base	31	12	30	13	05	13	24	.....	
	179	58	15	00	00	00	00	.....	
W. Base, Obs. Spot, Yellow	97	27	00	26	52	26	54	.....	
Obs. Spot, Yellow, W. Base	13	48	15	48	08	48	07	.....	
Yellow, W. Base, Obs. Spot	68	45	08	45	00	44	59	.....	
	180	00	23	00	00	00	00	.....	
Yellow, E. Base, W. Base	72	43	31	43	31	43	25	.....	
E. Base, W. Base, Yellow	68	57	22	57	18	57	21	.....	
W. Base, Yellow, E. Base	38	19	15	19	11	19	14	.....	
	180	00	12	00	00	00	00	.....	

QUADRILATERAL No. 1.

YELLOW, EAST BASE, WEST BASE, OBSERVATION SPOT.

	Stations.	Letter.	Angle.	Computation.
			o ′ ″	L S = 14,329.686 ft.
Yellow.  W. Base. E. Base.	W. Base.	L	68 57 21	3.9687204 R S = 14,005.8 ft.
	E. Base.	R	72 43 25	9.7924340
	Yellow.	S	38 19 14	4.1762864 4.1762864
			180 00 00	9.9799503 9.9700215
				4.1562367 4.1463079
Obs. Spot.  W. Base. Yellow.				4.1562367
	W. Base.	L	68 44 59	9.9963199
	Yellow.	R	13 48 07	4.1599167 4.1599167
	Obs. Spot.	S	97 26 54	9.9904188
			180 00 00	3.5375491 4.1293355
				L S = 3,447.865
				R S = 13,469
Obs. Spot.  E. Base. Yellow.				4.1463079
	E. Base.	L	61 39 09	9.9614855
	Yellow.	R	52 07 21	4.1848224 4.1848224
	Obs. Spot.	S	66 13 30	9.8972528 9.9445242
			180 00 00	4.0820752 4.1293466
				L S = 12,080.23
				R S = 13,469.35
Obs. Spot.  W. Base. E. Base.				3.9687204
	W. Base.	L	137 42 20	9.7146443
	E. Base.	R	11 04 16	4.2540761 4.2540761
	Obs. Spot.	S	31 13 24	9.2833627 9.8279769
			180 00 00	3.5374388 4.0820530
				L S = 3,446.98
				R S = 12,079.63

SUMMARY.

Length of base line by measurement = 9,305.076 feet.

	Feet.	
W. Base to Yellow	= 14329.686	
E. Base to Yellow	= 14005.8	
W. Base to Obs. Spot	= 3447.856	2d Comp. = 3446.98 = 1050.81 meters.
Yellow to Obs. Spot	= 13469.	2d Comp. = 13469.35 = 4105.57 meters.
E. Base to Obs. Spot	= 12080.23	2d Comp. = 12079.63 = 3682.2 meters.

QUADRILATERAL No. 2.

YELLOW, EAST BASE, MIST, JACK.

	Measured angles.			1st Adj.		2d Adj.		3d Adj.	
	°	′	″	′	″	′	″	′	″
Jack, Yellow, E. Base	111	19	41	19	28	19	08	19	13
Yellow, E. Base, Mist	63	33	38	33	25	33	21	33	26
E. Base, Mist, Jack	151	43	15	43	02	43	12	43	17
Mist, Jack, Yellow	33	24	18	24	05	24	00	24	04
	360	00	52	00	00	59	41	00	00
Jack, Yellow, Mist	54	00	50	00	46	00	51	.....	
Mist, Yellow, E. Base	57	18	34	18	22	18	22	.....	
	111	19	24	19	08	19	13	.....	
Yellow, E. Base, Jack	46	15	45	14	58	14	48	.....	
Jack, E. Base, Mist	17	17	53	18	23	18	37	.....	
	63	33	38	33	21	33	25	.....	
E. Base, Mist, Yellow	59	08	26	08	13	08	12	.....	
Yellow, Mist, Jack	92	35	03	34	59	35	05	.....	
	151	43	29	43	12	43	17	.....	
Mist, Jack, E. Base	10	57	22	57	52	58	06	.....	
E. Base, Jack, Yellow	22	26	56	26	08	25	59	.....	
	33	24	18	24	00	24	05	.....	
Jack, Yellow, Mist	54	00	50	00	46	00	51	.....	
Yellow, Mist, Jack	92	35	03	34	59	35	05	.....	
Mist, Jack, Yellow	33	24	18	24	15	24	04	.....	
	180	00	11	00	00	00	00	.....	
Jack, E. Base, Mist	17	17	53	18	23	18	37	.....	
E. Base, Mist, Jack	151	43	15	43	45	43	17	.....	
Mist, Jack, E. Base	10	57	22	57	52	58	06	.....	
	179	58	30	00	00	00	00	.....	
Mist, Yellow, E. Base	57	18	34	18	22	18	22	.....	
Yellow, E. Base, Mist	63	33	38	33	25	33	26	.....	
E. Base, Mist, Yellow	59	08	26	08	13	08	12	.....	
	180	00	38	00	00	00	00	.....	
Jack, Yellow, E. Base	111	19	41	18	54	19	13	.....	
Yellow, E. Base, Jack	46	15	45	14	58	14	48	.....	
E. Base, Jack, Yellow	22	26	56	26	08	25	59	.....	
	180	02	22	00	00	00	00	.....	

QUADRILATERAL No. 2.

YELLOW, EAST BASE, MIST, JACK.

	Stations.	Letter.	Angle.			Computation.	
			°	′	″	4.1463079	
Mist.	E. Base.	L	63	33	26	9.9336873	
	Yellow.	R	57	18	22	4.2126206	4.2126206
	Mist.	S	59	08	12	9.9250894	9.9520072
			180	00	00	4.1377100	4.1646278
						L S=13731.24	
						R S=14609.28	
L 14,005.8 P							
E. Base. Yellow.							
						4.1646278	
Jack.	Mist.	L	92	35	05	9.7407549	
	Yellow.	R	54	00	51	4.4238729	4.4238729
	Jack.	S	33	24	04	9.9080326	9.9995580
			180	00	00	4.3319055	4.4234309
						L S=21473.5	
						R S=26511.29	
L R							
Mist. Yellow.							
						4.1463079	
Jack.	Yellow.	L	111	19	13	9.5816126	
	E. Base.	R	46	14	48	4.5646953	4.5646953
	Jack.	S	22	25	59	9.8587319	9.9692120
			180	00	00	4.4234272	4.5339073
						L S=26511.07	
						R S=34190.64	
L R							
Yellow. E. Base.							
						4.1377100	
Jack.	Mist.	L	151	43	17	9.2793622	
	E. Base.	R	17	18	37	4.8583478	4.8583478
	Jack.	S	10	58	06	9.4735544	9.6755580
			180	00	00	4.3319022	4.5339058
						L S=21473.47	
						R S=34190.52	
L R							
Mist. E. Base.							

SUMMARY.

E. Base to Mist	=13731.24	
Mist to Yellow	=14609.28	
Mist to Jack	=21473.5	2d Comp.=21473.47
Yellow to Jack	=26511.29	2d Comp.=26511.07
E. Base to Jack	=34190.64	2d Comp.=34190.52

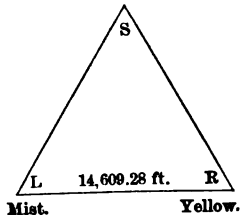
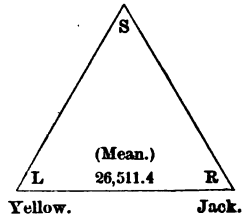
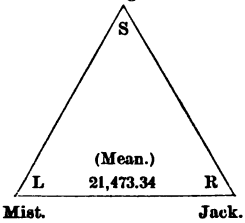
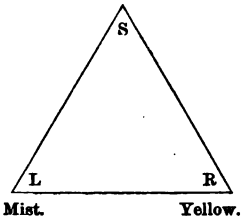
QUADRILATERAL No. 3.

RIDGE, YELLOW, MIST, JACK.

	Measured angles.			1st Adj.		2d Adj.		3d Adj.	
	°	′	″	′	″	′	″	′	″
Ridge, Yellow, Mist	109	01	42	02	07	01	51	01	58
Yellow, Mist, Jack	92	35	03	35	23	35	20	35	27
Mist, Jack, Ridge	124	06	41	07	11	07	02	07	09
Jack, Ridge, Yellow	34	15	03	15	19	15	20	15	26
	359	58	29	00	00	59	33	00	00
Mist, Yellow, Jack	54	00	50	00	46	00	29	00	33
Jack, Yellow, Ridge	55	00	42	01	19	01	22	01	25
	109	01	32	02	05	01	51	01	58
Yellow, Mist, Ridge	56	02	48	03	13	03	14	03	18
Ridge, Mist, Jack	36	32	15	32	21	32	06	32	09
	92	35	03	35	34	35	20	35	27
Mist, Jack, Yellow	33	24	18	24	14	23	57	24	00
Yellow, Jack, Ridge	90	42	22	43	01	43	05	43	09
	124	06	40	07	15	07	02	07	09
Jack, Ridge, Mist	19	20	48	20	53	20	39	20	22
Mist, Ridge, Yellow	14	54	15	54	40	54	41	54	44
	34	15	03	15	33	15	20	15	26
Ridge, Yellow, Mist	109	01	42	02	07	02	05	01	58
Yellow, Mist, Ridge	56	02	48	03	13	03	14	03	18
Mist, Ridge, Yellow	14	54	15	54	40	54	41	54	44
	179	58	45	00	00	00	00	00	00
Yellow, Mist, Jack	92	35	03	35	00	35	34	35	27
Mist, Jack, Yellow	33	24	18	24	14	23	57	24	00
Jack, Yellow, Mist	54	00	50	00	46	00	29	00	33
	180	00	11	00	00	00	00	00	00
Mist, Jack, Ridge	124	06	41	06	46	07	15	07	09
Jack, Ridge, Mist	19	20	48	20	53	20	39	20	42
Ridge, Mist, Jack	36	32	15	32	20	32	06	32	09
	179	59	44	00	00	00	00	00	00
Jack, Ridge, Yellow	34	15	03	15	40	15	33	15	26
Ridge, Yellow, Jack	55	00	42	01	19	01	22	01	25
Yellow, Jack, Ridge	90	42	22	43	01	43	05	43	09
	179	58	07	00	00	00	00	00	00

QUADRILATERAL No. 3.

RIDGE, YELLOW, MIST, JACK.

	Stations.	Letter.	Angle.			Computation.	
			°	′	″	4.1646278	
Jack.  Mist. Yellow.	Mist.	L	92	35	27	9.7407421	
	Yellow.	R	54	00	33	4.4238857	4.4238857
	Jack.	S	33	24	00	9.9080081	9.9095559
			180	00	00	4.3318938	4.4234416
						L S=21,473.05	
						R S=26,511.95	
Ridge.  Yellow. Jack.						4.4234327	
	Yellow.	L	55	01	25	9.7504382	
	Jack.	R	90	43	09	4.6720945	4.6720945
	Ridge.	S	34	15	26	9.9999658	9.9134898
			180	00	00	4.6720603	4.5864843
						L S=47,093.42	
						R S=38,590.84	
Ridge.  Mist. Jack.						4.3318996	
	Mist.	L	36	32	09	9.5201632	
	Jack.	R	124	07	09	4.8117364	4.8117364
	Ridge.	S	19	20	42	9.9179636	9.7747545
			180	00	00	4.7297000	4.5865009
						L S=53,666.099	
						R S=38,592.32	
Ridge.  Mist. Yellow.						4.1646278	
	Mist.	L	56	03	18	9.4105055	
	Yellow	R	109	01	58	4.7541223	4.7541223
	Ridge.	S	14	54	44	9.9755844	9.9188552
			180	00	00	4.7297067	4.6729775
						L S=53,666.92	
						R S=47,095.3	

SUMMARY.

Mist to Jack =21,473.05
Yellow to Jack =26,511.95
Yellow to Ridge =47,093.42 2d Comp.=47,095.3
Jack to Ridge =38,590.84 2d Comp.=38,592.32
Two of first and one of second=38,591.33.
Mist to Ridge =53,666.099 2d Comp.=53,666.03

QUADRILATERAL No. 4.

TAIL, RIDGE, WHALE, JACK.

	Measured angles.			1st Adj.		2d Adj.		3d Adj.	
	°	′	″	′	″	′	″	′	″
Jack, Tail, Ridge	57	14	00	13	46	14	00	14	07
Tail, Ridge, Whale	141	33	00	32	46	32	59	33	06
Ridge, Whale, Jack	35	00	37	00	24	59	42	59	49
Whale, Jack, Tail	126	13	18	13	04	12	51	12	58
	360	00	55	00	00	59	32	00	00
Jack, Tail, Whale	33	59	30	59	30	59	40		
Whale, Tail, Ridge	23	14	30	14	30	14	27		
	57	14	00	14	00	14	07		
Tail, Ridge, Jack	61	20	38	20	10	19	53		
Jack, Ridge, Whale	80	12	48	12	49	13	13		
	141	36	26	32	59	33	06		
Ridge, Whale, Tail	15	12	30	12	30	12	27		
Tail, Whale, Jack	19	47	12	47	12	47	22		
	34	59	42	59	42	59	49		
Whale, Jack, Ridge	64	46	33	46	34	46	58		
Ridge, Jack, Tail	61	26	45	26	17	26	00		
	126	13	18	12	51	12	58		
Tail, Ridge, Whale	141	33	00	33	00	33	06		
Ridge, Whale, Tail	15	12	30	12	30	12	27		
Whale, Tail, Ridge	23	14	30	14	30	14	27		
	180	00	00	00	00	00	00		
Tail, Ridge, Jack	61	20	38	20	10	19	53		
Ridge, Jack, Tail	61	26	45	26	17	26	00		
Jack, Tail, Ridge	57	14	00	13	33	14	07		
	180	01	23	00	00	00	00		
Tail, Jack, Whale	126	13	18	13	18	12	58		
Jack, Whale, Tail	19	47	12	47	12	47	22		
Whale, Tail, Jack	33	59	30	59	30	59	40		
	180	00	00	00	00	00	00		
Ridge, Jack, Whale	64	46	33	46	34	46	58		
Jack, Whale, Ridge	35	00	37	00	37*	59	49		
Whale, Ridge, Jack	80	12	48	12	49	13	13		
	179	59	58	00	00	00	00		

*34°.

QUADRILATERAL No. 4.

TAIL, RIDGE, WHALE, JACK.

	Station.	Letter.	Angle.	Computation.	
			o ′ ″	4.5864898	
Tail.			61 26 00	9.9247443	
S	Jack.	L	61 19 53	4.6617455	4.6617455
(Mean.)	Ridge.	R	57 14 07	9.9432021	9.9436238
L 38,591.33 R	Tail.	S	180 00 00	4.6049476	4.6053693
Jack. Ridge.				L S=40, 266. 84	
				R S=40, 305. 96	
				4.5864898	
Whale.					
S	Jack.	L	64 46 58	9.7585582	
	Ridge.	R	80 13 13	4.8279316	4.8279316
L R	Whale.	S	34 59 49	9.9936426	9.9565041
Jack. Ridge.			180 00 00	4.8215742	4.7844357
				L S=66, 309. 26	
				R S=60, 874. 55	
				4.8215742	
Tail.					
S	Jack.	L	126 12 58	9.7474992	
	Whale.	R	19 47 22	5.0740750	5.0740750
L R	Tail.	S	33 59 40	9.5296415	9.9067628
Jack. Whale.			180 00 00	4.6037165	4.9808378
				L S=40, 152. 86	
				R S=95, 683. 32	
				4.7844357	
Tail.					
S	Whale.	L	15 12 27	9.5961536	
	Ridge.	R	141 33 06	5.1882821	5.1882821
L R	Tail.	S	23 14 27	9.7936568	9.4188240
Whale. Ridge.			180 00 00	4.9819389	5.6071061
				L S=95, 927. 58	
				R S=40, 467. 47	

SUMMARY.

Jack to Tail	=40, 266. 84	2d Comp.	=40, 152. 86
Ridge to Tail	=40, 305. 96	2d Comp.	=40, 467. 47
Jack to Whale	=66, 309. 26		
Ridge to Whale	=60, 874. 55		
Whale to Tail	=95, 683. 32	2d Comp.	=95, 927. 58

Two of 1st and one of 2d =95, 764. 74 ft.

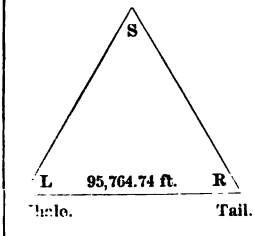
QUADRILATERAL No. 5.

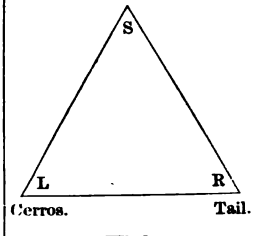
CERROS, WHALE, TAIL, NATIVIDAD.

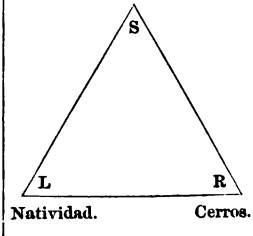
	Measured angles.	1st Adj.	2d Adj.	3d Adj.
	° ′ ″	′ ″	′ ″	′ ″
Cerros, Whale, Tail	37 32 00	32 37	33 08	52 56
Whale, Tail, Natividad	145 51 00	51 38	52 30	52 17
Tail, Natividad, Cerros	132 04 30	05 08	04 56	04 44
Natividad, Cerros, Whale	44 30 00	30 37	30 15	30 03
	359 57 30	00 00	00 49	00 00
Cerros, Whale, Natividad	22 22 43	23 38	24 04	.....
Natividad, Whale, Tail	15 09 30	09 30	08 52	.....
	37 32 13	33 08	32 56	.....
Whale, Tail, Cerros	119 57 00	57 00	56 32	.....
Cerros, Tail, Natividad	25 54 45	55 30	55 46	.....
	145 51 45	52 30	52 18	.....
Tail, Natividad, Whale	18 59 30	59 30	58 51	.....
Whale, Natividad, Cerros	113 04 30	05 26	05 53	.....
	132 04 00	04 56	04 44	.....
Natividad, Cerros, Tail	21 58 30	59 15	59 30	.....
Tail, Cerros, Whale	22 31 00	31 00	30 32	.....
	44 29 30	30 15	30 02	.....
Cerros, Whale, Tail	37 32 00	32 00	32 56	.....
Whale, Tail, Cerros	119 57 00	57 00	56 32	.....
Tail, Cerros, Whale	22 31 00	31 00	30 32	.....
	180 00 00	00 00	00 00	.....
Tail, Natividad, Cerros	132 04 30	05 15	04 44	.....
Natividad, Cerros, Tail	21 58 30	59 15	59 30	.....
Cerros, Tail, Natividad	25 54 45	55 30	55 46	.....
	179 57 45	00 00	00 00	.....
Natividad, Cerros, Whale	44 30 00	30 56	30 03	.....
Cerros, Whale, Natividad	22 22 43	23 38	24 04	.....
Whale, Natividad, Cerros	113 04 30	05 26	05 53	.....
	179 57 13	00 00	00 00	.....
Whale, Tail, Natividad	145 51 00	51 00	52 17	.....
Tail, Natividad, Whale	18 59 30	59 30	58 51	.....
Natividad, Whale, Tail	15 09 30	09 30	08 52	.....
	180 00 00	00 00	00 00	.....

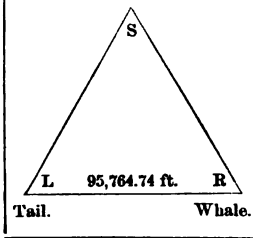
QUADRILATERAL No. 5.

CERROS, WHALE, TAIL, NATIVIDAD.









Stations.	Letter.	Angle.			Computation.	
		°	′	″	4.9812057	
Whale.	L	37	32	56	9.5830023	
Tail.	R	119	56	32	5.3982034	5.3982034
Cerros.	S	22	30	32	9.9377820	9.7849296
		180	00	00	5.3359854	5.1831330
					L S=216,763.11	
					R S=152,451.97	
					5.1831330	
Cerros.	L	21	59	30	9.8706483	
Tail.	R	25	55	46	5.3124847	5.3124847
Natividad.	S	132	04	44	9.6407438	9.5734190
		180	00	00	4.9532285	4.8859037
					L S=89,790.1	
					R S=76,896.	
					4.9532285	
Natividad.	L	113	05	53	9.5810256	
Cerros.	R	44	30	03	5.3722029	5.3722029
Whale.	S	22	24	04	9.8456682	9.9637098
		180	00	00	5.2178711	5.3359127
					L S=165,147.15	
					R S=216,726.85	
					4.9812057	
Tail.	L	145	52	17	9.5122197	
Whale.	R	15	08	52	5.4689860	5.4689860
Natividad.	S	18	58	51	9.4171552	9.7490034
					4.8861412	5.2179894
					L S=76,938.05	
					R S=165,192.13	

SUMMARY.

Whale to Cerros	=216,763.11	2d Comp.=	216,726.85
Tail to Cerros	=152,451.97		
Cerros to Natividad	= 89,790.1		
Tail to Natividad	= 76,896	2d Comp.=	76938.05
Whale to Natividad	=165,147.15	2d Comp.=	165192.13

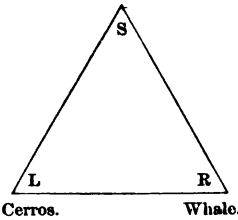
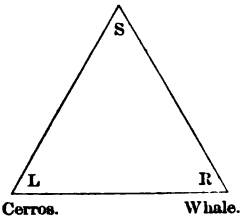
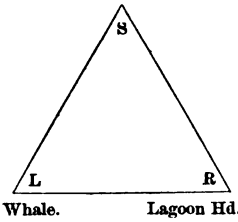
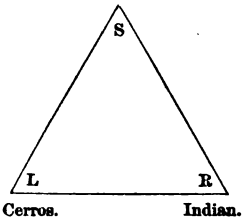
QUADRILATERAL No. 6.

INDIAN, LAGOON HEAD, WHALE, CERROS.

	Measured angles.			Special 1st Adj.		2d Adj.		3d Adj.	
	°	′	″	′	″	′	″	′	″
Indian, Lagoon Head, Whale	116	25	52	24	52	23	57	25	03
Lagoon Head, Whale, Cerros	94	36	30	36	30	35	36	31	43
Whale, Cerros, Indian	87	57	15	56	15	55	21	56	25
Cerros, Indian, Lagoon Head	61	06	00	06	00	05	06	06	49
	360	05	37	03	37	00	00	00	00
Lagoon Head, Indian, Whale	32	40	00	39	33	40	25	.....	
Whale, Indian, Cerros	28	26	00	25	33	26	25	.....	
	61	06	00	05	06	06	50	.....	
Indian, Lagoon Head, Cerros	79	50	30	49	35	50	14	.....	
Whale, Lagoon Head, Cerros	36	35	22	34	22	34	53	.....	
	116	25	52	23	57	25	07	.....	
Lagoon Head, Whale, Indian	30	54	08	.....		54	32	.....	
Indian, Whale, Cerros	63	36	45	.....		37	10	.....	
	94	30	53	.....		31	42	.....	
Lagoon Head, Cerros, Indian	39	03	12	02	21	02	57	.....	
Lagoon Head, Cerros, Whale	48	54	03	53	00	53	34	.....	
	87	57	15	55	21	56	31	.....	
Indian, Cerros, Lagoon Head	39	03	12	03	18	02	57	.....	
Cerros, Indian, Lagoon Head	61	06	00	06	06	06	49	.....	
Indian, Lagoon Head, Cerros	79	50	30	50	36	50	14	.....	
	179	59	42	00	00	00	00	.....	
Indian, Whale, Lagoon Head	30	54	08	54	08	54	32	.....	
Whale, Indian, Lagoon Head	32	40	00	40	00	40	25	.....	
Whale, Lagoon Head, Indian	116	25	52	25	52	25	03	.....	
	180	00	00	00	00	00	00	.....	
Whale, Cerros, Lagoon Head	48	54	03	52	18	53	34	.....	
Cerros, Lagoon Head, Whale	36	35	22	33	37	34	53	.....	
Cerros, Whale, Lagoon Head	94	36	30	34	15	31	43	.....	
	180	05	55	00	10	00	10	.....	
Cerros, Indian, Whale	28	26	00	26	00	26	25	.....	
Indian, Cerros, Whale	87	57	15	57	15	56	25	.....	
Indian, Whale, Cerros	63	36	45	36	45	37	10	.....	
	180	00	00	00	00	00	00	.....	

QUADRILATERAL No. 6.

INDIAN, LAGOON HEAD, WHALE, CERROS.

	Stations.	Letter.	Angle.			Computation.	
Indian.			°	′	″	4.8588379	
	Cerros.	L	87	56	25	9.6778281	
	Whale.	R	63	37	10	5.1810098	5.1810098
	Indian.	S	28	26	25	9.9522414	9.9997229
			180	00	00	5.1332512	5.1807327
						L S=135,909.93 yds.	
						R S=151,617.07	
Cerros. Whale.							
Lagoon Head.						4.8588379	
	Cerros.	L	48	53	34	9.7752201	
	Whale.	R	94	31	43	5.0836178	5.0836178
	Lagoon Head.	S	36	34	53	9.9986419	9.8770720
			180	00	00	5.0822597	4.9606898
						L S=120,853.61	
						R S= 91,344.606	
Cerros. Whale.							
Indian.						4.9606898	
	Whale.	L	30	54	32	9.7322753	
	Lagoon Head.	R	116	25	03	5.2284145	5.2284145
	Indian.	S	32	40	25	9.9521024	9.7106879
			180	00	00	5.1805169	4.9391024
						L S=151,532.9	
						R S= 86,916.59	
Whale. Lagoon Hd.							
Lagoon Head.						5.1332512	
	Cerros.	L	39	02	57	9.9931320	
	Indian.	R	61	06	49	5.1401192	5.1401192
	Lagoon Head.	S	79	50	14	9.9422955	9.7993316
			180	00	00	5.0824147	4.9394508
						L S=120,896.76	
						R S= 86,986.28	
Cerros. Indian.							

SUMMARY.

Cerros to Lagoon Head=120,853.61 yds.	2d Comp.=120,896.76	Mean=120,875.18
Cerros to Indian =135,909.93 yds.		
Whale to Indian =151,617.07 yds.	2d Comp.=151,532.9	
Whale to Lagoon Head= 91,344.606		
Indian to Lagoon Head= 86,916.59	2d Comp.= 86,986.28	

TRIANGLE No. 7.

CERROS, LAGOON HEAD, PEAK.

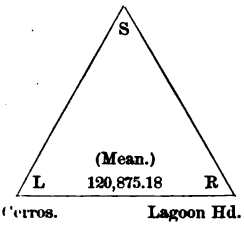
NOTE.—The first two triangles below constitute step No. 7, as they could not be

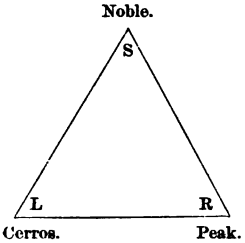
	Measured angles.	1st Adj.	2d Adj.	3d Adj.
Cerros, Lagoon Head, Peak, Noble (see Quadrilateral Adjustment, page 15).				
	° ′ ″	′ ″	′ ″	′ ″
Cerros, Lagoon Head, Peak	72 51 32	50 54		
Lagoon Head, Peak, Cerros	59 32 45	31 45		
Peak, Cerros, Lagoon Head	47 38 00	37 21		
	180 02 17	00 00		
Triangle No. 8.—Cerros, Peak, Noble.				
Cerros, Peak, Noble	23 03 20	02 20		
Peak, Noble, Cerros	145 01 00	00 40		
Noble, Cerros, Peak	11 58 30	57 00		
	180 02 50	00 00		
Triangle No. 9.—Noble, Peak, Harris.				
Noble, Peak, Harris	63 08 53	09 03		
Peak, Harris, Noble	82 38 30	38 40		
Harris, Noble, Peak	34 12 07	12 17		
	179 59 30	00 00		

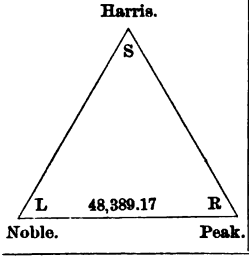
TRIANGLE No. 7.

CERROS, LAGOON HEAD, PEAK.

worked as a quadrilateral, Lagoon Head and Noble not being interchangeable.







Stations.	Letter.	Angle.			Computation.	
		°	′	″	5.0823371	
Cerros.	L	72	50	54	9.9354505	
Lagoon Head.	R	59	31	45	5.1468866	5.1468866
Peak.	S	47	37	21	9.9802432	9.8684799
		180	00	00	5.1271298	5.0153665
					L S=134,007.72	
					R S=103,601.6	
					5.1271298	
Cerros.	L	23	02	20	9.7584710	
Peak.	R	145	00	40	5.3686588	5.3686588
Noble.	S	11	57	00	9.5925718	9.3160921
		180	00	00	4.9612306	4.6847509
					L S=91,459.9	
					R S=48,389.17	
					4.6847509	
Noble.	L	63	09	03	9.9964113	
Peak.	R	82	38	40	4.6883396	4.6883396
Harris.	S	34	12	17	9.9504614	9.7498534
		180	00	00	4.6388010	4.4382430
					L S=43,531.25	
					R S=27,431.1	

SUMMARY.

Lagoon Head to Peak = 103,601.6 yds.
Cerros to Noble = 91,459.9 yds.
Cerros to Peak = 134,007.72 yds.
Noble to Peak = 48,389.17 yds. Per page 32 = 48,412.55 yds. Mean = 48,400.86 yds.
Noble to Harris = 43,531.25 yds.
Peak to Harris = 27,431.1 yds

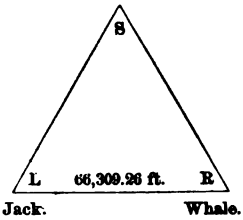
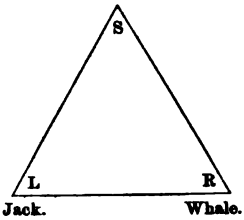
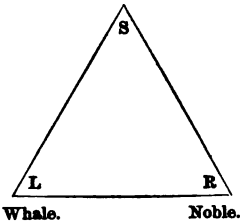
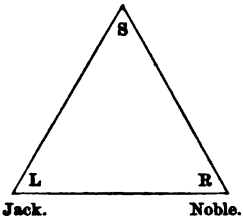
QUADRILATERAL No. 8.

JACK, WHALE, NOBLE, SUMMIT.

	Measured angles.			1st Adj.		2d Adj.		3d Adj.	
	°	′	″	′	″	′	″	′	″
Jack, Whale, Summit	115	55	00	55	00	55	19	55	32
Whale, Summit, Noble	45	48	22	46	29	46	47	46	59
Summit, Noble, Jack	144	12	00	12	00	12	19	11	54
Noble, Jack, Whale	54	04	38	5	16	5	35	5	35
	360	00	00	58	45	00	00	00	00
Jack, Whale, Noble	78	45	07	45	17	45	30	.....	
Noble, Whale, Summit	37	09	53	10	02	10	02	.....	
	115	55	00	55	19	55	32	.....	
Summit, Noble, Whale	97	03	38	03	48	3	11	.....	
Whale, Noble, Jack	47	08	22	08	31	8	43	.....	
	144	12	00	12	19	11	54	.....	
Noble, Jack, Summit	14	36	12	36	40	.....		.....	
Summit, Jack, Whale	39	28	26	28	55	.....		.....	
	54	04	38	5	35	.....		.....	
Angles at Summit supplied	.....			.....		.....		.....	
Jack, Whale, Summit	155	55	00	55	19	.....		.....	
Whale, Summit, Jack	24	36	34	35	46	.....		.....	
Summit, Jack, Whale	39	28	26	28	55	.....		.....	
	180	00	00	00	00	.....		.....	
Whale, Summit, Noble	45	46	29	46	47	.....		.....	
Summit, Noble, Whale	97	03	38	3	11	.....		.....	
Noble, Whale, Summit	37	09	53	10	02	.....		.....	
	180	00	00	00	00	.....		.....	
Summit, Noble, Jack	144	12	00	12	19	.....		.....	
Noble, Jack, Summit	14	36	12	36	40	.....		.....	
Jack, Summit, Noble	21	11	48	11	01	.....		.....	
	180	00	00	00	00	.....		.....	
Noble, Jack, Whale	54	04	38	5	16	5	35	5	47
Jack, Whale, Noble	78	45	07	45	45	45	17	45	30
Whale, Noble, Jack	47	08	22	8	59	8	31	8	43
	179	58	07	00	00	59	23	00	00

QUADRILATERAL No. 8.

JACK, WHALE, NOBLE, SUMMIT.

	Stations.	Letter.	Angle.			Computation.	
Noble.			°	′	″	4.8215742	
	Jack.	L	54	05	47	9.9651518	
	Whale.	R	78	45	30	4.9564224	4.9564224
	Noble.	S	47	08	43	9.9915965	9.9084876
			180	00	00	4.9480989	4.9649100
						L S=88,717.43 ft.	
						R S=73,267.27 ft.	
L 66,309.26 ft. R							
Jack. Whale.							
Summit.						4.8215742	
	Jack.	L	39	28	55	9.6193220	
	Whale.	R	115	55	19	5.2022522	5.2022522
	Summit.	S	24	35	46	9.9539482	9.8033444
			180	00	00	5.1562004	5.0055966
						L S=143,284.8	
						R S=101,297.1	
L R							
Jack. Whale.							
Summit.						4.8649020	
	Whale.	L	37	10	02	9.8553155	
	Noble.	R	97	03	11	5.0095865	5.0095865
	Summit.	S	45	46	47	9.9967011	9.7811399
			180	00	00	5.0062876	3.7907264
						L S=101,458.2	
						R S= 61,672.7	
L R							
Whale. Noble.							
Summit.						4.9480009	
	Jack.	L	14	36	40	9.5579375	
	Noble.	R	144	12	19	5.3900034	5.3900034
	Summit.	S	21	11	01	9.7670690	9.4018433
			180	00	00	5.1571324	4.7919067
						L S=143,592.7	
						R S= 61,930.8	
L R							
Jack. Noble.							

SUMMARY.

	Feet.		Feet.
Jack to Noble	= 88,717.43		
Whale to Noble	= 73,267.27		
Jack to Summit	=143,284.8	2d Comp.	=143,592.7
Whale to Summit	=101,297.1	2d Comp.	=101,458.2
Noble to Summit	= 61,762.7	2d Comp.	= 61,930.8

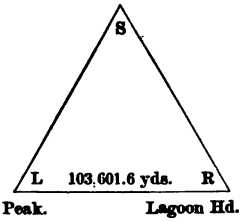
QUADRILATERAL No. 9.

CERROS, LAGOON HEAD, TOP, PEAK.

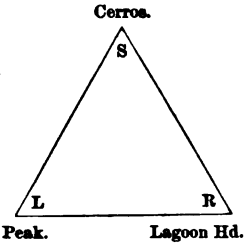
	Measured angles.			1st Adj.		2d Adj.		3d Adj.	
	°	′	″	′	″	′	″	′	″
Cerros, Lagoon Head, Top	137	54	00	54	00	53	53	53	52
Lagoon Head, Top, Peak	43	39	40	40	05	39	59	39	59
Top, Peak, Cerros	130	49	35	49	35	49	29	49	30
Peak, Cerros, Lagoon Head	47	36	45	36	45	36	39	36	39
	360	00	00	00	25	00	00	00	00
Top, Lagoon Head, Peak	65	02	15	.....		02	12	02	24
Peak, Lagoon Head, Cerros	72	51	45	.....		51	41	51	28
	137	54	00	.....		39	59	39	59
Peak, Top, Cerros	24	20	40	.....		20	50	20	50
Cerros, Top, Lagoon Head	19	19		.....		19	09	19	09
	43	39	40	.....		39	59	39	59
Top, Peak, Lagoon Head	71	16	50	17	15	17	12	17	25
Lagoon Head, Peak, Cerros	59	32	45	32	20	32	17	32	05
	130	49	35	49	35	49	29	49	30
Peak, Cerros, Top	24	49	45	.....		49	42	49	42
Top, Cerros, Lagoon Head	22	47	00	.....		46	57	46	57
	47	36	45	.....		36	39	36	39
Cerros, Lagoon Head, Peak	72	51	45	51	20	51	41	51	28
Lagoon Head, Peak, Cerros	59	32	45	32	20	32	17	32	05
Peak, Cerros, Lagoon Head	47	36	45	36	20	36	39	36	27
	180	01	15	00	00	00	37	00	00
Lagoon Head, Peak, Top	71	16	50	17	15	17	12	17	25
Peak, Top, Lagoon Head	43	39	40	40	05	39	59	40	11
Top, Lagoon Head, Peak	65	02	15	02	40	02	12	02	24
	179	58	45	00	00	59	23	00	00
Cerros, Lagoon Head, Top	137	54	00	.....		53	53	53	54
Lagoon Head, Top, Cerros	19	19	00	.....		19	09	19	09
Top, Cerros, Lagoon Head	22	47	00	.....		46	57	46	57
	180	00	00	.....		59	59	00	00
Cerros, Top, Peak	24	20	40	.....		20	50	20	50
Top, Peak, Cerros	130	49	35	.....		49	29	49	28
Peak, Cerros, Top	24	49	45	.....		49	42	49	42
	180	00	00	.....		00	01	00	00

QUADRILATERAL No. 9.

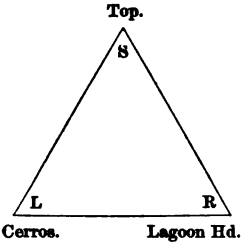
CERROS, LAGOON HEAD, TOP, PEAK.



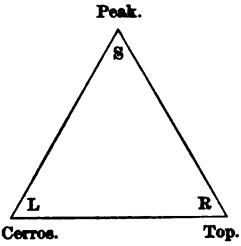
Stations.	Letter.	Angle.			Computation.	
		′	′	″	5.0153665	
Peak.	L	71	17	25	9.8891638	
Lagoon Head.	R	65	02	24	5.1762027	5.1762027
Top.	S	43	40	11	9.9574168	9.9764214
		180	00	00	5.1336195	5.1526241
					L S = 136,025.2	
					R S = 142,109.84	



Stations.	Letter.	Angle.			Computation.	
					5.0153665	
Peak.	L	59	32	05	9.8683761	
Lagoon Head.	R	72	51	28	5.1469904	5.1469904
Cerros.	S	47	36	27	9.9802653	9.9354753
		180	00	00	5.1272557	5.0824657
					L S = 134,046.6	
					R S = 120,910.98	



Stations.	Letter.	Angle.			Computation.	
					5.0824657	
Cerros.	L	22	46	57	9.5196050	
Lagoon Head.	R	137	53	54	5.5628607	5.5628607
Top.	S	19	19	09	9.8263653	9.5879735
		180	00	00	5.3892260	5.1508342
					L S = 245,033.76	
					R S = 141,525.3	



Stations.	Letter.	Angle.			Computation.	
					5.3892260	
Cerros.	L	24	49	42	9.8789330	
Top.	R	24	20	50	5.5102930	5.5102930
Peak.	S	130	49	28	9.6151769	9.6231468
		180	00	00	5.1254699	5.1334398
					L S = 133,496.5	
					R S = 135,968.9	

SUMMARY.

Peak to Top	= 136,015.2 yds.	2d Comp. = 135,968.9 yds.	
Lagoon Head to Top	= 142,109.84 yds.	2d Comp. = 141,525.3 yds.	
Peak to Cerros	= 134,046.6 yds.	2d Comp. = 133,496.5 yds.	
Lagoon Head to Cerros	= 120,910.98 yds.		
Cerros to Top	= 245,033.76 yds.		

TRIANGLE No. 10.

NOBLE, PEAK, HARRIS.

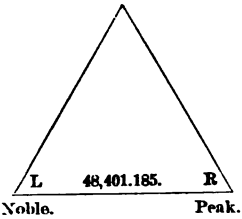
NOTE.—This is worked with the two different values of Noble, Peak.

	Measured angles.			1st Adj.		2d Adj.	3d Adj.
	°	′	″	′	″		
Noble, Peak, Harris	63	08	53	09	03	.....	.....
Peak, Harris, Noble	82	38	30	38	40	.....	.....
Harris, Noble, Peak	34	12	07	12	17	.....	.....
	179	59	30	00	00	.....	.....

TRIANGLE No. 10.

NOBLE, PEAK, HARRIS.

A trifling error of 3 yards was afterwards discovered in the base, but was allowed to remain.



Noble Peak=48, 389. 17

Stations.	Letter.	Angle.	Computation.	
		o ′ ″	4. 6847509	
Noble.	L	34 12 17	9. 9964113	
Peak.	R	63 09 03	4. 6883396	4. 6883396
Harris.	S	82 38 40	9. 9504614	9. 7498534
		180 00 00	4. 6388060	4. 4382980
			L S=43, 541. 76	
			R S=27, 434. 56	
			4. 6847509	
			9. 9964113	
			4. 6883396	4. 6883396
			9. 9504614	9. 7498534
			4. 6388010	4. 4382430
			L S=43, 531. 25	
			R S=27, 431. 1	

SUMMARY.

Noble to Harris=43, 541. 76 and 43, 531. 25 mean=43. 536. 555
Peak to Harris=27, 434. 56 and 27, 431. 1 mean=27, 432. 83

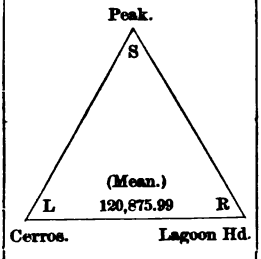
CERROS, LAGOON HEAD, PEAK, NOBLE.

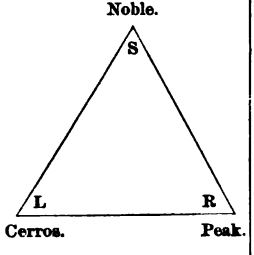
NOTE.--This adjustment is made on the quadrilateral system to use in connection with the triangle adjustment to give a mean determination.

	Measured angles.			1st Adj.		2d Adj.		3d Adj.		4th Adj.	
	°	′	″	′	″	′	″	′	″	′	″
Noble, Cerros, Lagoon Head	59	36	30	35	14	34	48	35	00	35	00
Peak, Lagoon Head, Cerros	72	51	32	50	15	50	15	50	28	50	30
Noble, Peak, Lagoon Head	82	36	05	34	48	34	23	34	36	34	36
Cerros, Noble, Peak	145	01	00	59	43	59	43	59	56	59	54
	360	05	07	00	00	59	09	00	00	00	00
Noble, Cerros, Peak	11	58	30	57	34	57	40				
Peak, Cerros, Lagoon Head	47	38	00	37	14	37	20				
	59	36	30	34	48	35	00				
Peak, Lagoon Head, Noble											
Noble, Lagoon Head, Cerros											
Noble, Peak, Cerros	23	03	20	02	23	02	29				
Cerros, Peak, Lagoon Head	59	32	45	32	00	32	07				
	82	36	05	34	23	34	36				
Cerros, Noble, Lagoon Head											
Lagoon Head, Noble, Peak											
Cerros, Lagoon Head, Peak	72	51	32	50	46	50	28	50	30		
Peak, Cerros, Lagoon Head	47	38	00	37	14	37	20	37	21		
Cerros, Peak, Lagoon Head	59	32	45	32	00	32	07	32	09		
	180	02	17	00	00	59	55	00	00		
Lagoon Head, Peak, Noble	82	36	05	36	05						
Peak, Noble, Cerros	145	01	00	00	03	*59	56	59	54		
Noble, Peak, Cerros	23	03	20	02	23	02	29	02	27		
Noble, Cerros, Peak	11	58	30	57	34	57	40	57	39		
	180	02	50	00	00	00	05	00	00		
Noble, Cerros, Lagoon Head											

*144°

CERROS, LAGOON, HEAD, PEAK, NOBLE.





Stations.	Letter.	Angles.			Computation.	
		°	′	″	5.0823401	
Cerros.	L	47	37	21	9.9354803	
Lagoon Head.	R	72	50	30	5.1468598	5.1468598
Peak.	S	59	32	09	9.9802276	9.9864799
		180	00	00	5.1270874	5.0153397
					L S = 133,994.63	
					R S = 103,595.23	
					5.1270874	
Cerros.	L	11	57	39	9.7586094	
Peak.	R	23	02	27	5.3684780	5.3684780
Noble.	S	144	59	54	9.5926065	9.3164799
		180	00	00	4.9610845	4.6849579
					L S = 91,429.1	
					R S = 48,412.55	

SUMMARY.

Cerros to Peak	= 133,994.63
Lagoon Head to Peak	= 103,595.23
Cerros to Noble	= 91,429.1
Peak to Noble	= 48,412.55

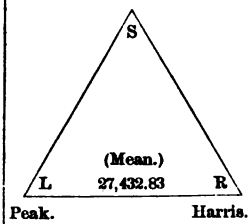
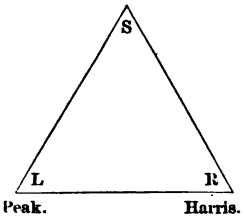
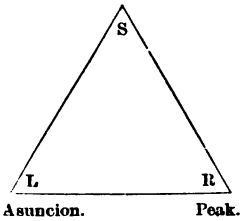
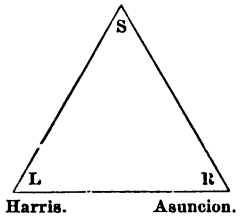
QUADRILATERAL No. 10.

PEAK, TABLE, ASUNCION, HARRIS.

	Measured angles.			1st Adj.		2d Adj.		3d Adj.	
	°	′	″	′	″	′	″	′	″
Harris, Peak, Table	80	36	15	36	20	36	23	36	42
Peak, Table, Asuncion	45	34	37	34	42	36	07	36	26
Table, Asuncion, Harris	140	33	35	33	40	33	41	34	00
Asuncion, Harris, Peak	92	15	12	15	18	12	32	12	52
	359	59	39	00	00	58	43	00	00
Harris, Peak, Asuncion	41	43	05	44	18				
Asuncion, Peak, Table	39	53	18	52	24				
	81	36	23	36	42				
Peak, Table, Harris	28	54	29	54	35				
Harris, Table, Asuncion	16	41	38	41	52				
	45	36	07	36	27				
Table, Asuncion, Peak	94	32	03	31	10				
Peak, Asuncion, Harris	46	01	38	02	50				
	140	33	41	34	00				
Asuncion, Harris, Table	22	43	54	44	08				
Table, Harris, Peak	69	28	38	28	43				
	92	12	32	12	51				
Peak, Table, Asuncion	45	34	37	34	39	36	26		
Table, Asuncion, Peak	94	32	01	32	03	31	10		
Asuncion, Peak, Table	39	53	15	53	18	52	24		
	179	59	53	00	00	00	00		
Peak, Asuncion, Harris	46	01	34	01	38	02	50		
Asuncion, Harris, Peak	92	15	12	15	17	12	52		
Harris, Peak, Asuncion	41	43	00	43	05	44	18		
	179	59	46	00	00	00	00		
Harris, Table, Peak	28	53	52	54	29	54	35		
Table, Peak, Harris	81	36	15	36	53	36	42		
Peak, Harris, Table	69	28	00	28	38	28	43		
	179	58	07	00	00	00	00		
Harris, Asuncion, Table	140	33	35	34	28	34	00		
Asuncion, Table, Harris	16	40	45	41	38	41	52		
Table, Harris, Asuncion	22	43	00	43	54	44	08		
	179	57	20	00	00	00	00		

QUADRILATERAL No. 10.

PEAK, TABLE, ASUNCION, HARRIS.

	Stations.	Letter.	Angle.			Computation.	
Asuncion.			o	'	"	4.4382707	
	Peak.	L	41	44	18	9.8572795	
	Harris.	R	92	12	52	4.5809912	4.5809912
Peak. Harris.	Asuncion.	S	46	02	50	9.9996755	9.8232980
			180	00	00	4.5806667	4.4042892
						L S = 38,077.348	
						R S = 25,368.17	
Table.						4.4382707	
	Peak.	L	81	36	42	9.6843173	
	Harris.	R	69	28	43	4.7539534	4.7539534
Peak. Harris.	Table.	S	28	54	35	9.9715270	9.9953289
			180	00	00	4.7254804	4.7492823
						L S 53,147.19	
						R S = 56,141.28	
Table.						4.5806667	
	Asuncion.	L	94	31	10	9.8540393	
	Peak.	R	39	52	24	4.7266274	4.7266274
Asuncion. Peak.	Table.	S	46	36	26	9.8069207	9.9986475
			180	00	00	4.5335481	4.7252749
						L S = 34,162.38	
						R S = 53,122.06	
Table.						4.4042892	
	Harris.	L	22	44	08	9.4583709	
	Asuncion.	R	140	34	00	4.9459183	4.9459183
Harris. Asuncion.	Table.	S	16	41	52	9.8028968	9.5871252
			180	00	00	4.7488151	4.5330435
						L S = 56,080.923	
						R S = 34,122.7	

SUMMARY.

Peak to Asuncion	= 38,077.348		
Harris to Asuncion	= 25,368.17		
Harris to Table	= 56,141.28	2d Comp.	= 56,080.923
Peak to Table	= 53,147.19	2d Comp.	= 53,122.06
Asuncion to Table	= 34,162.38	2d Comp.	= 34,122.7

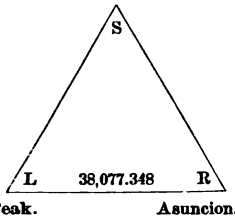
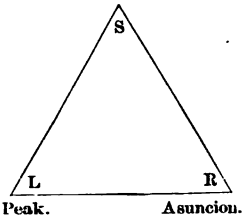
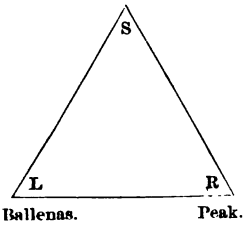
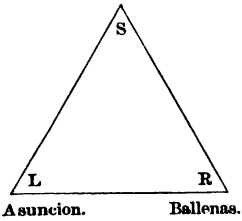
QUADRILATERAL No. 11.

PEAK, ASUNCION, TABLE, BALLENAS.

	Measured angles.			1st Adj.		2d Adj.		3d Adj.	
	°	′	″	′	″	′	″	′	″
Peak, Asuncion, Table	94	32	01	32	03	32	00	31	59
Asuncion, Table, Ballenas	152	34	30	34	40	34	26	34	32
Table, Ballenas, Peak	42	11	29	11	29	11	26	11	27
Ballenas, Peak, Asuncion	70	42	00	42	02	41	58	42	02
	360	00	00	00	14	00	00	00	00
Peak, Asuncion, Ballenas	79	37	55	37	56	.....		.....	
Ballenas, Asuncion, Table	14	54	06	54	03	.....		.....	
	94	32	01	31	59	.....		.....	
Ballenas, Table, Peak	106	59	52	59	52	59	50	.....	
Peak, Table, Asuncion	45	34	37	34	40	34	42	.....	
	152	34	29	34	32	34	32	.....	
Peak, Ballenas, Asuncion	29	40	05	40	06	.....		.....	
Asuncion, Ballenas, Table	12	31	24	31	21	.....		.....	
	42	11	29	11	27	.....		.....	
Ballenas, Peak, Table	30	48	45	48	45	48	44	.....	
Table, Peak, Asuncion	39	53	15	53	17	53	18	.....	
	70	42	00	42	02	42	02	.....	
Peak, Asuncion, Table	94	32	01	32	03	32	00	.....	
Asuncion, Table, Peak	45	34	37	34	40	34	42	.....	
Table, Peak, Asuncion	39	53	15	53	17	53	18	.....	
	179	59	53	00	00	00	00	.....	
Asuncion, Table, Ballenas	152	34	30	34	36	.....		.....	
Table, Ballenas, Asuncion	12	31	24	31	21	.....		.....	
Ballenas, Asuncion, Table	14	54	06	54	03	.....		.....	
	180	00	00	00	00	.....		.....	
Table, Ballenas, Peak	42	11	23	11	26	.....		.....	
Ballenas, Peak, Table	30	48	45	48	44	.....		.....	
Peak, Table, Ballenas	106	59	52	59	50	.....		.....	
	180	00	00	00	00	.....		.....	
Ballenas, Peak, Asuncion	70	42	00	41	58	.....		.....	
Peak, Asuncion, Ballenas	79	37	55	37	56	.....		.....	
Asuncion, Ballenas, Peak	29	40	05	40	06	.....		.....	
	180	00	00	00	00	.....		.....	

QUADRILATERAL No. 11.

PEAK, ASUNCION, TABLE, BALLENAS.

	Stations.	Letter.	Angle.			Computation.	
Ballenas.			o	'	"	4.5806667	
	Peak.	L	70	41	58	9.6945833	
	Asuncion.	R	79	37	56	4.8860834	4.8860834
	Ballenas.	S	29	40	06	9.9928507	9.9748789
			180	00	00	4.8789341	4.8609623
						L S=75,671.79	
						R S=72,604.3	
L 38,077.348 R							
Peak. Asuncion.							
Table.						4.5806667	
	Peak.	L	39	53	18	9.8538247	
	Asuncion.	R	94	32	00	4.7268420	4.7268420
	Table.	S	45	34	42	9.9986392	9.8070568
			180	00	00	4.7254812	4.5338988
						L S=53,147.29	
						R S=34,189.977	
Peak. Asuncion.							
Table.						4.8789341	
	Ballenas.	L	42	11	26	9.9806028	
	Peak.	R	30	48	44	4.8983313	4.8983313
	Table.	S	106	59	50	9.7094617	9.8271097
			180	00	00	4.6077930	4.7254410
						L S=40,531.533	
						R S=53,142.38	
Ballenas. Peak.							
Table.						4.8609623	
	Asuncion.	L	14	54	03	9.6632874	
	Ballenas.	R	12	31	21	5.1976749	5.1976749
	Table.	S	152	34	36	9.3361053	9.4101812
			180	00	00	4.5337802	4.6078561
						L S=34,180.64	
						R S=40,537.42	
Asuncion. Ballenas.							

SUMMARY.

Peak to Ballenas	=75,671.79		
Asuncion to Ballenas	=72,604.3		
Peak to Table	=53.147.29	2d Comp. =53,142.38	Per quad. No. 10=53,147.19 and 53,122.06 Mean=53,139.73
Asuncion to Table	=34,189.977	2d Comp. =34,180.64	
Ballenas to Table	=40,531.533	2d Comp. =40,537.42	

QUADRILATERAL No. 12.

PEAK, BALLENAS, RUGGED, TABLE.

	Measured angles.			1st Adj.		2d Adj.		3d Adj.	
	°	′	″	′	″	′	″	′	″
Peak, Ballenas, Rugged	58	29	06	29	06	29	09	.....	
Ballenas, Rugged, Table	141	19	47	19	56	19	59	.....	
Rugged, Table, Peak	129	22	22	22	22	22	25	.....	
Table, Peak, Ballenas	30	48	45	48	25	48	27	.....	
	360	00	00	59	49	00	00	.....	
Peak, Ballenas, Table	42	11	23	11	23	11	32	.....	
Table, Ballenas, Rugged	16	17	43	17	43	17	37	.....	
	58	29	06	29	06	29	09	.....	
Ballenas, Rugged, Peak	102	56	58	56	56	56	54	.....	
Peak, Rugged, Table	38	22	49	23	00	23	05	.....	
	141	19	47	19	56	19	59	.....	
Rugged, Table, Ballenas	22	22	30	22	30	*22	24	.....	
Ballenas, Table, Peak	106	59	52	59	52	00	01	.....	
	129	22	22	22	22	22	25	.....	
Table, Peak, Rugged	12	14	15	14	26	14	30	.....	
Rugged, Peak, Ballenas	18	34	00	33	59	33	57	.....	
	30	48	15	48	25	48	27	.....	
Peak, Ballenas, Rugged	58	29	06	29	05	29	09	.....	
Ballenas, Rugged, Peak	102	56	58	56	56	56	54	.....	
Rugged, Peak, Ballenas	18	34	00	33	59	33	57	.....	
	180	00	04	00	00	00	00	.....	
Ballenas, Rugged, Table	141	19	47	.....		19	59	.....	
Rugged, Table, Ballenas	22	22	30	.....		22	24	.....	
Table, Ballenas, Rugged	16	17	43	.....		17	37	.....	
	180	00	00	.....		00	00	.....	
Rugged, Table, Peak	129	22	22	22	34	22	25	.....	
Table, Peak, Rugged	12	14	15	14	26	14	30	.....	
Peak, Rugged, Table	38	22	49	23	00	23	05	.....	
	179	59	26	00	00	00	00	.....	
Table, Peak, Ballenas	30	48	45	.....		48	27	.....	
Peak, Ballenas, Table	42	11	23	.....		11	32	.....	
Ballenas, Table, Peak	106	59	52	.....		*00	01	.....	
	180	00	00	.....		00	00	.....	

*107°

QUADRILATERAL No. 12.

PEAK, BALLENAS, RUGGED, TABLE.

	Stations.	Letter.	Angle.			Computation.	
Ballenas.			°	′	″	4.7254194	
S	Peak.	L	30	48	27	9.8271236	
(Mean.) 53,139.73	Table.	R	107	00	01	4.8982958	4.8982958
L R	Ballenas.	S	42	11	32	9.9805957	9.7094017
Peak. Table.			180	00	00	4.8788915	4.6076975
						L S=75,664.38	
						R S=40,522.62	
Rugged.						4.7254194	
S	Peak.	L	12	14	30	9.7930488	
	Table.	R	129	22	25	4.9323706	4.9323706
	Rugged.	S	38	23	05	9.8881940	9.3264087
L R			180	00	00	4.8205646	4.2587793
Peak. Table.						L S=66,155.29	
						R S=18,145.934	
Rugged.						4.8788915	
S	Peak.	L	18	33	57	9.9888142	
	Ballenas.	R	58	29	09	4.8900773	4.8900773
	Rugged.	S	102	56	54	9.9307000	9.5029650
L R			180	00	00	4.8207773	4.3930423
Peak. Ballenas.						L S=66,187.7	
						R S=24,719.7	
Rugged.						4.6076975	
S	Ballenas.	L	16	17	37	9.7957356	
	Table.	R	22	22	24	4.8119619	4.8119619
	Rugged.	S	141	19	59	9.5805145	9.4470253
L R			180	00	00	4.3924764	4.2589872
Ballenas. Table.						L S=24,687.46	
						R S=18,196.48	

SUMMARY.

Peak to Ballenas	=75,664.38		
Table to Ballenas	=40,522.62		
Peak to Rugged	=66,155.29	2d Comp.=	66,187.7
Table to Rugged	=18,145.934	2d Comp.=	18,196.48
Ballenas to Rugged	=24,719.7	2d Comp.=	24,687.46

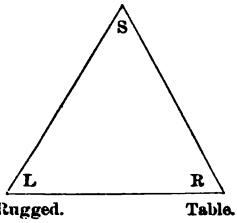
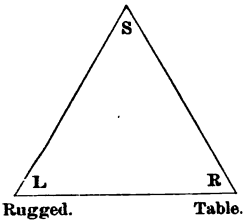
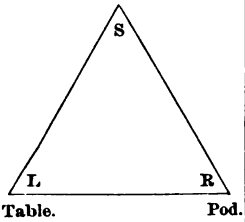
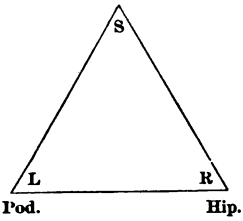
QUADRILATERAL No. 13.

RUGGED, POD, HIP, TABLE.

	Measured angles.	1st Adj.	2d Adj.	3d Adj.	4th Adj.
	° ′ ″	′ ″	′ ″	′ ″	′ ″
Rugged, Pod, Hip	126 41 30	40 54	39 15	39 37	39 36
Pod, Hip, Table	75 55 11	54 35	54 27	54 50	54 50
Hip, Table, Rugged	98 47 38	47 02	47 27	47 50	47 51
Table, Rugged, Pod	58 38 06	37 29	37 20	37 43	37 43
	360 02 25	00 00	58 29	00 00	00 00
Rugged, Pod, Table	82 04 27	04 45	05 05		
Table, Pod, Hip	44 34 43	34 28	34 31		
	126 39 10	39 15	39 36		
Pod, Hip, Rugged	24 04 30	03 51	04 28		
Rugged, Hip, Table	51 50 53	50 36	50 22		
	75 55 23	54 27	54 50		
Hip, Table, Pod	59 30 51	30 36	30 39		
Pod, Table, Rugged	39 16 33	16 51	17 12		
	98 47 24	47 27	47 51		
Table, Rugged, Hip	29 22 18	22 02	21 48		
Hip, Rugged, Pod	29 15 58	15 18	15 55		
	58 38 16	37 20	37 43		
Rugged, Pod, Hip	126 41 30	40 51	39 37		
Pod, Hip, Rugged	24 04 30	03 51	04 28		
Hip, Rugged, Pod	29 15 58	15 18	15 55		
	180 01 58	00 00	00 00		
Pod, Hip, Table	75 55 11	54 56	54 50		
Hip, Table, Pod	59 30 51	30 36	30 39		
Table, Pod, Hip	44 34 43	34 28	34 31		
	180 00 45	00 00	00 00		
Hip, Table, Rugged	98 47 38	47 22	47 50		
Table, Rugged, Hip	29 22 18	22 02	21 48		
Rugged, Hip, Table	51 50 53	50 36	50 22		
	180 00 49	00 00	00 00		
Table, Rugged, Pod	58 38 06	38 24	37 43		
Rugged, Pod, Table	82 04 27	04 45	05 05		
Pod, Table, Rugged	39 16 33	16 51	17 12		
	179 59 06	00 00	00 00		

QUADRILATERAL No. 13.

RUGGED, POD, HIP, TABLE.

	Stations.	Letter.	Angle.	Computation.	
			o ′ ″	4.2593836	
Pod.  Rugged. Table.	Rugged.	L	58 37 43	9.9958425	
	Table.	R	39 17 12	4.2635411	4.2635411
	Pod.	S	82 05 05	9.8015414	9.9313617
			180 00 00	4.0650825	4.1949028
				L S=11,616.7	
				R S=15,664	
Hip.  Rugged. Table.				4.2593836	
	Rugged.	L	29 21 48	9.8955786	
	Table.	R	98 47 50	4.3638050	4.3638050
	Hip.	S	51 50 22	9.9948606	9.6905027
			180 00 00	4.3586656	4.0543077
				L S=22,839.4	
				R S=11,332.03	
Hip.  Table. Pod.				4.1949028	
	Table.	L	59 30 39	9.9867409	
	Pod.	R	44 34 31	4.2081619	4.2081619
	Hip.	S	75 54 50	9.8462416	9.9353688
			180 00 00	4.0544035	4.1435307
				L S=11,334.5	
				R S=13,916.5	
Rugged.  Pod. Hip.				4.1435307	
	Pod.	L	126 39 37	9.6891791	
	Hip.	R	24 04 28	4.4543516	4.4543516
	Rugged.	S	29 15 55	9.6105785	9.9042771
			180 00 00	4.0649301	4.3586287
				L S=11,612.62	
				R S=22,836.46	

SUMMARY.

Rugged to Pod	=11,616.7	2d Comp.	=11,612.62
Table to Pod	=15,664		
Rugged to Hip	=22,839.4	2d Comp.	=22,836.46
Table to Hip	=11,332.03	2d Comp.	=11,334.5
Pod to Hip	=13,916.5		

QUADRILATERAL No. 14.

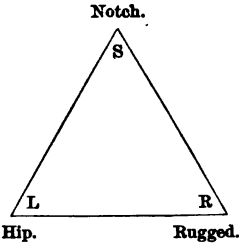
RUGGED, NOTCH, ABRE, HIP.

	Measured angles.	1st Adj.	2d Adj.	3d Adj.	4th Adj.
	° ′ ″	′ ″	′ ″	′ ″	′ ″
Rugged, Notch, Abre	140 27 15	27 08	27 11	27 08	27 08
Notch, Abre, Hip	55 52 39	52 32	52 24	52 22	52 35
Abre, Hip, Rugged	60 53 44	53 37	53 40	53 37	53 37
Hip, Rugged, Notch	102 46 50	46 43	46 56	46 53	46 40
	360 00 28	00 00	00 11	00 00	00 00
Rugged, Notch, Hip	47 18 53	18 50	19 01	19 08	.....
Hip, Notch, Abre	93 08 22	08 18	08 07	08 00	.....
	140 27 15	27 08	27 08	27 08	.....
Notch, Abre, Rugged	17 46 59	46 56	46 57	46 57	.....
Rugged, Abre, Hip	38 05 40	05 36	05 38	05 38	.....
	55 52 39	52 32	52 35	52 35	.....
Abre, Hip, Notch	30 59 45	59 41	59 31	59 25	.....
Notch, Hip, Rugged	29 53 59	53 56	54 06	54 12	.....
	60 53 44	53 37	53 37	53 37	.....
Hip, Rugged, Abre	.....	.....	*00 36	00 45	.....
Abre, Rugged, Notch	.....	.....	†45 46	45 55	.....
	102 43 22	46 43	46 22	46 40	.....
Rugged, Notch, Abre	140 27 15	27 11	27 08	27 08	.....
Notch, Abre, Rugged	17 46 59	46 56	46 57	46 57	.....
Abre, Rugged, Notch	21 45 56	45 53	45 55	45 55	....
	180 00 10	00 00	00 00	00 00	.....
Notch, Abre, Hip	55 52 39	52 24	52 22	52 35	.....
Abre, Hip, Notch	30 59 45	59 30	59 31	59 25	.....
Hip, Notch, Abre	93 08 22	08 06	08 07	08 00	.....
	180 00 46	00 00	00 00	00 00	.....
Abre, Hip, Rugged	60 53 44	53 40	53 37	53 37	.....
Hip, Rugged, Abre	81 00 47	00 43	00 45	00 45	.....
Rugged, Abre, Hip	38 05 40	05 37	05 38	05 38	.....
	180 00 11	00 00	00 00	00 00	.....
Hip, Rugged, Notch	102 46 50	46 56	46 53	46 40	.....
Rugged, Notch, Hip	47 18 53	18 59	19 01	19 08	.....
Notch, Hip, Rugged	29 53 59	54 05	54 06	54 12	.....
	179 59 42	00 00	00 00	00 00	.....

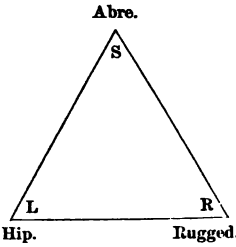
* 81° † 21°

QUADRILATERAL No. 14.

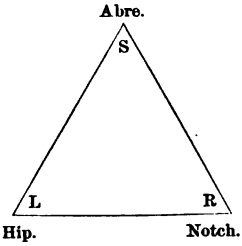
RUGGED, NOTCH, ABRE, HIP.



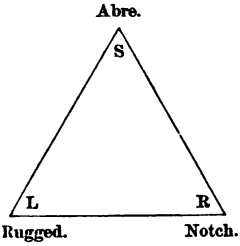
Stations.	Letter.	Angle.			Computation.	
		°	′	″	4.3586874	
Hip.	L	29	54	12	9.8663689	
Rugged.	R	102	46	40	4.4923185	4.4923185
Notch.	S	47	19	08	9.9891094	9.6976984
		180	00	00	4.4814279	4.1900169
					L S = 30, 298. 972	
					R S = 15, 488. 77	



Stations.	Letter.	Angle.			Computation.	
					4.3586874	
Hip.	L	60	53	37	9.7902513	
Rugged.	R	81	00	45	4.5684361	4.5684361
Abre.	S	38	05	38	9.9946349	9.9413713
		180	00	00	4.5630710	4.5098074
					L S = 36, 565. 454	
					R S = 32, 345. 015	



Stations.	Letter.	Angle.			Computation.	
					4.4814279	
Hip.	L	30	59	25	9.9179407	
Notch.	R	93	08	00	4.5634872	4.5634872
Abre.	S	55	52	35	9.9993503	9.7117166
		180	00	00	4.5628375	4.2752038
					L S = 36, 545. 798	
					R S = 18, 845. 333	



Stations.	Letter.	Angle.			Computation.	
					4.1900169	
Rugged.	L	21	45	55	9.4848754	
Notch.	R	140	27	08	4.7051415	4.7051415
Abre.	S	17	46	57	9.8039495	9.5691457
		180	00	00	4.5090910	4.2742872
					L S = 32, 291. 7	
					R S = 18, 805. 6	

SUMMARY.

Hip to Notch	= 30, 298. 972		
Rugged to Notch	= 15, 488. 77		
Hip to Abre	= 36, 565. 454	2d Comp.	= 36, 545. 798
Rugged to Abre	= 32, 345. 015	2d Comp.	= 32, 291. 7
Notch to Abre	= 18, 845. 333	2d Comp.	= 18, 805. 6

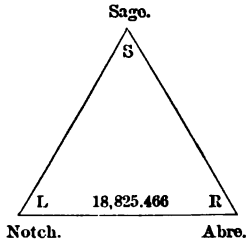
QUADRILATERAL No. 15.

NOTCH, SAGE, DICK, ABRE.

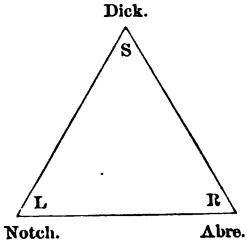
	Measured angles.			1st Adj.		2d Adj.		3d Adj.	
	°	′	″	′	″	′	″	′	″
Notch, Sage, Dick	116	21	00	21	27	21	21	20	34
Sage, Dick, Abre	77	28	07	29	22	29	16	27	59
Dick, Abre, Notch	134	31	00	30	40	30	34	31	21
Abre, Notch, Sage	31	39	53	38	55	38	49	40	06
	360	00	00	00	00	00	00	00	00
Notch, Sage, Abre	42	57	03	56	07	55	29	.....	
Abre, Sage, Dick	73	23	10	24	27	25	06	.....	
	116	20	13	20	34	20	35	.....	
Sage, Dick, Notch	51	22	56	23	25	23	48	.....	
Notch, Dick, Abre	26	04	50	04	34	04	10	.....	
	77	27	46	27	59	27	58	.....	
Dick, Abre, Sage	29	05	00	06	17	06	55	.....	
Sage, Abre, Notch	105	26	00	25	04	24	25	.....	
	134	31	00	31	21	31	20	.....	
Abre, Notch, Dick	19	25	08	24	52	24	29	.....	
Dick, Notch, Sage	12	14	45	15	14	15	38	.....	
	31	39	53	40	06	40	07	.....	
Notch, Sage, Dick	116	21	00	21	27	21	21	20	34
Sage, Dick, Notch	51	22	56	23	22	23	25	23	48
Dick, Notch, Sage	12	14	45	15	11	15	14	15	38
	179	58	41	00	00	00	00	00	00
Sage, Dick, Abre	77	28	07	29	22	29	16	27	59
Dick, Abre, Sage	29	05	00	06	14	06	17	06	55
Abre, Sage, Dick	73	23	10	24	24	24	27	25	06
	179	56	17	00	00	00	00	00	00
Dick, Abre, Notch	134	31	00	30	40	30	34	31	21
Abre, Notch, Dick	19	25	08	24	49	24	52	24	29
Notch, Dick, Abre	26	04	50	04	31	04	34	04	10
	180	00	58	00	00	00	00	00	00
Abre, Notch, Sage	31	39	53	38	55	38	49	40	06
Notch, Sage, Abre	42	57	03	56	04	56	07	55	29
Sage, Abre, Notch	105	26	00	25	01	25	04	24	25
	180	02	56	00	00	00	00	00	00

QUADRILATERAL No. 15.

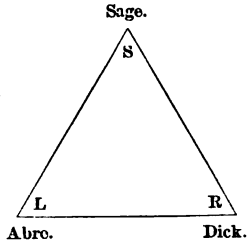
NOTCH, SAGE, DICK, ABRE.



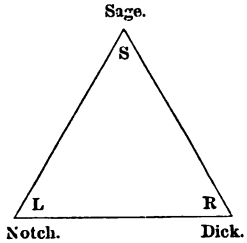
Stations.	Letter.	Angle.			Computation.	
		°	′	″	4.2747458	
Notch.	L	31	40	06	9.8331706	
Abre.	R	105	24	25	4.4415752	4.4415752
Sage.	S	42	55	29	9.9841056	9.7201605
		180	00	00	4.4256808	4.1617357
					L S—26,649	
					R S=14,512.28	



Stations.	Letter.	Angle.			Computation.	
					4.2747458	
Notch.	L	19	24	29	9.6429195	
Abre.	R	134	31	21	4.6317263	4.6317263
Dick.	S	26	04	10	9.8530744	9.3215221
		180	00	00	4.4848007	4.1532483
					L S=30,535.19	
					R S=14,231.42	



Stations.	Letter.	Angle.			Computation.	
					4.1532483	
Abre.	L	29	06	55	9.9815532	
Dick.	R	77	27	59	4.1716951	4.1716951
Sage.	S	73	25	06	9.9895249	9.6871439
		180	00	00	4.1612200	3.8588390
					L S=14,495.06	
					R S= 7,225.02	



Stations.	Letter.	Angle.			Computation.	
					4.4848007	
Notch.	L	12	15	38	9.9523833	
Dick.	R	51	23	48	4.5324174	4.5324174
Sage.	S	116	20	34	9.8929202	9.3270680
		180	00	00	4.4253376	3.8594854
					L S=26,627.945	
					R S= 7,235.78	

SUMMARY.

Notch to Sage =23,349	2d Comp. =26,627.945
Abre to Sage =14,512.28	2d Comp. =14,495.06
Notch to Dick =30,535.19	
Abre to Dick =14,231.42	
Dick to Sage = 7,225.02	2d Comp. = 7,235.78

QUADRILATERAL No. 16.

SAGE, NORTH BASE, SOUTH BASE, DICK.

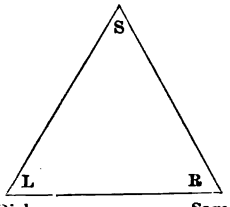
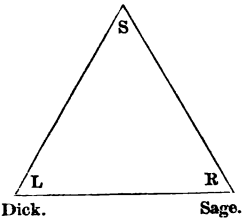
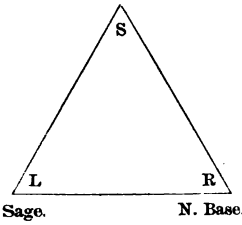
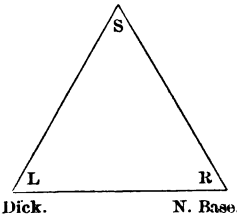
NOTE.—See also quadrilateral 21.

	Measured angles.	1st Adj.	2d Adj.	3d Adj.
	° ′ ″	′ ″	′ ″	′ ″
Sage, N. Base, S. Base	137 26 05	26 17	26 24	26 20
N. Base, S. Base, Dick	80 56 05	56 17	56 20	56 16
S. Base, Dick, Sage	74 06 22	06 33	06 32	06 29
Dick, Sage, N. Base	67 30 42	30 53	30 58	30 55
	359 59 14	00 00	00 14	00 00
Sage, N. Base, Dick	80 46 45	47 08	47 13	.....
Dick, N. Base, S. Base	56 39 20	39 16	39 08	.....
	137 26 05	26 24	26 21	.....
N. Base, S. Base, Sage	19 14 53	15 14	15 17	.....
Sage, S. Base, Dick	61 41 12	41 06	40 59	.....
	80 56 05	56 20	56 16	.....
S. Base, Dick, N. Base	42 24 48	24 44	24 36	.....
N. Base, Dick, Sage	31 41 26	41 48	41 52	.....
	74 06 14	06 32	06 28	.....
Dick, Sage, S. Base	44 12 43	12 38	12 32	.....
S. Base, Sage, N. Base	23 18 00	18 20	18 23	.....
	67 30 43	30 58	30 55	.....
Sage, N. Base, S. Base	137 26 05	26 26	26 20	.....
N. Base, S. Base, Sage	19 14 53	15 14	15 17	.....
S. Base, Sage, N. Base	23 18 00	18 20	18 23	.....
	179 58 58	00 00	00 00	.....
N. Base, S. Base, Dick	80 56 05	56 00	56 16	.....
S. Base, Dick, N. Base	42 24 48	24 44	24 36	.....
Dick, N. Base, S. Base	56 39 20	39 16	39 08	.....
	180 00 13	00 00	00 00	.....
S. Base, Dick, Sage	74 06 22	06 16	06 29	.....
Dick, Sage, S. Base	44 12 43	12 38	12 32	.....
Sage, S. Base, Dick	61 41 12	41 06	40 59	.....
	180 00 17	00 00	00 00	.....
Dick, Sage, N. Base	67 30 42	31 04	30 55	.....
Sage, N. Base, Dick	80 46 45	47 08	47 13	.....
N. Base, Dick, Sage	31 41 26	41 48	41 52	.....
	179 58 53	00 00	00 00	.....

QUADRILATERAL No. 16.

SAGE, NORTH BASE, SOUTH BASE, DICK.

NOTE.—See also quadrilateral 21.

	Stations.	Letter.	Angle.			Computation.	
N. Base.						3.8591863	
	Dick.	L	31	41	52	9.9943610	
	Sage.	R	67	30	55	3.8648253	3.8648253
	N. Base.	S	80	47	13	9.9056633	9.7205220
			180	00	00	3.8304886	3.5853473
						L S = 6,768.44	
						R S = 3,848.995	
Dick. Sage.							
S. Base.						3.8591863	
	Dick.	L	74	06	29	9.9446490	
	Sage.	R	44	12	22	3.9145373	3.9145373
	S. Base.	S	61	40	59	9.8434049	9.9830757
			180	00	00	3.7579422	3.8976130
						L S = 5,727.2	
						R S = 7,899.743	
Dick. Sage.							
S. Base.						3.5853473	
	Sage.	L	23	18	23	9.5182091	
	N. Base.	R	137	26	20	4.0671382	4.0671382
	S. Base.	S	19	15	17	9.8301883	9.5973089
			180	00	00	3.8973265	3.6644471
						L S = 7,894.534	
						R S = 4,617.927	
Sage. N. Base.							
S. Base.						3.8304886	
	Dick.	L	42	24	36	9.9945450	
	N. Base.	R	56	39	08	3.8359436	3.8359436
	S. Base.	S	80	56	16	9.9218681	9.8289377
			180	00	00	3.7578117	3.6648813
						L S = 5,725.477	
						R S = 4,622.547	
Dick. N. Base.							

SUMMARY.

Dick to N. Base	= 6,768.44		
Sage to N. Base	= 3,848.995		
Dick to S. Base	= 5,727.2	2d Comp. =	5,725.477
Sage to S. Base	= 7,899.743	2d Comp. =	7,894.534
N. Base to S. Base	= 4,617.927	2d Comp. =	4,622.547

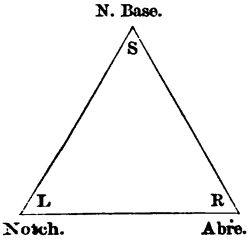
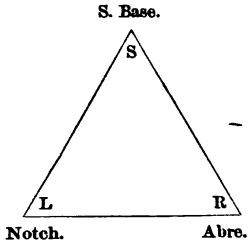
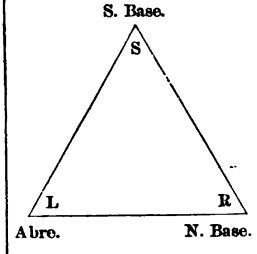
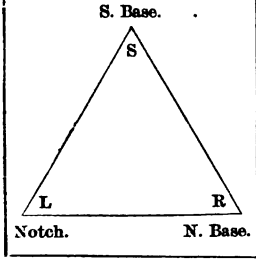
QUADRILATERAL No. 17.

NOTCH, NORTH BASE, SOUTH BASE, ABRE.

	Measured angles			1st Adj.		2d Adj.		3d Adj.	
	°	′	″	′	″	′	″	″	″
Notch, N. Base, S. Base	148	48	00	48	44	48	42	48	07
N. Base, S. Base, Abre	68	25	20	25	21	25	20	25	22
S. Base, Abre, Notch	128	25	00	24	56	24	54	24	49
Abre, Notch, N. Base	22	17	20	17	15	17	14	11	32
	360	00	00	00	16	00	00	00	00
Notch, N. Base, Abre	34	34	25	34	20	34	22	.....	.....
Abre, N. Base, S. Base	106	25	45	25	47	25	46	.....	.....
	140	48	00	48	07	48	07	.....	.....
N. Base, S. Base, Notch	34	25	00	25	21	25	00	.....	.....
Notch, S. Base, Abre	68	17	22	17	20	17	22	.....	.....
	102	42	22	42	41	42	22	.....	.....
S. Base, Abre, N. Base	21	01	40	01	45	01	42	.....	.....
N. Base, Abre, Notch	113	14	00	14	06	14	07	.....	.....
	134	15	40	15	51	15	49	.....	.....
Abre, Notch, S. Base	17	17	40	17	06	17	09	.....	.....
S. Base, Notch, N. Base	4	55	42	55	46	55	44	.....	.....
	22	13	20	13	12	13	13	.....	.....
Notch, N. Base, Abre	34	34	25	34	20	34	22	34	21
N. Base, Abre, Notch	113	14	00	14	06	14	06	14	07
Abre, Notch, N. Base	22	11	20	11	15	11	14	11	32
	179	59	45	00	00	00	00	00	00
N. Base, S. Base, Abre	68	25	20	25	21	25	20	25	22
S. Base, Abre, N. Base	21	01	42	01	45	01	43	10	42
Abre, N. Base, S. Base	106	33	45	33	46	33	47	13	46
	179	59	57	00	00	00	00	00	00
S. Base, Abre, Notch	128	25	00	24	56	24	54	24	49
Abre, Notch, S. Base	25	17	40	17	45	17	46	17	49
Notch, S. Base, Abre	26	17	22	17	19	17	20	17	22
	180	00	02	00	00	00	00	00	00
Notch, N. Base, S. Base	148	48	00	48	04	48	02	48	07
N. Base, S. Base, Notch	34	18	00	18	11	18	12	18	09
S. Base, Notch, N. Base	4	53	42	53	45	53	46	53	44
	179	59	50	00	00	00	00	00	00

QUADRILATERAL No. 17.

NOTCH, NORTH BASE, SOUTH BASE, ABRE.

	Stations.	Letter.	Angle.	Computation.	
			° ′ ″	4. 2747457	
	Notch.	L	32 11 32	9. 7539265	
	Abre.	R	113 14 07	4. 5208192	4. 5208192
	N. Base.	S	34 34 21	9. 9632647	9. 7265328
			180 00 00	4. 4840839	4. 2473520
				L S = 30, 484. 8	
				R S = 17, 674. 3	
				4. 2747457	
	Notch.	L	27 17 49	9. 6463116	
	Abre.	R	126 24 49	4. 6284341	4. 6284341
	S. Base.	S	26 17 22	9. 9056625	9. 6614361
			180 00 00	4. 5340966	4. 2898702
				L S = 34, 205. 55	
				R S = 19, 492. 57	
				4. 2473520	
	Abre.	L	13 10 42	9. 9400916	
	N. Base.	R	106 13 46	4. 3072604	4. 3072604
	S. Base.	S	60 35 32	9. 9823391	9. 3579019
			180 00 00	4. 2895995	3. 6651623
				L S = 19, 480. 47	
				R S = 4, 625. 538	
				4. 4840839	
	Notch.	L	4 53 44	9. 7509418	
	N. Base.	R	140 48 07	4. 7331421	4. 7331421
	S. Base.	S	34 19 09	9. 8007191	8. 9311508
			180 00 00	4. 5338612	3. 6642929
				L S = 34, 187	
				R S = 4, 616. 288	

SUMMARY.

Notch to N. Base	= 30, 484. 8	
Abre to N. Base	= 17, 674. 3	
Notch to S. Base	= 34, 205. 55	2d Comp. = 34, 187
Abre to S. Base	= 19, 492. 57	2d Comp. = 19, 480. 47
N. Base to S. Base	= 4, 625. 538	2d Comp. = 4, 616. 288

QUADRILATERAL No. 18.

TABLE, BALLENAS, HIP, NOTCH.

	Measured angles.	1st Adj.	2d Adj.	3d Adj.	4th Adj.
	° ′ ″	′ ″	′ ″	′ ″	′ ″
Table, Ballenas, Notch	49 20 53	20 53	20 59	20 47	20 46
Ballenas, Notch, Hip	107 41 30	41 30	41 36	41 41	41 41
Notch, Hip, Table	81 47 30	47 05	47 11	47 23	47 24
Hip, Table, Ballenas	121 10 07	10 07	10 14	10 09	10 09
	360 00 00	59 35	00 00	00 00	00 00
Table, Ballenas, Hip	11 47 53	.....	47 50	47 52	.....
Hip, Ballenas, Notch	37 33 00	.....	32 57	32 54	.....
	49 20 53	.....	20 47	20 46	.....
Ballenas, Notch, Table	86 20 00	.....	20 31	20 37	.....
Table, Notch, Hip	21 21 38	.....	21 10	21 04	.....
	107 41 38	.....	41 41	41 41	.....
Notch, Hip, Ballenas	34 45 30	.....	45 27	45 25	.....
Ballenas, Hip, Table	47 02 00	.....	01 56	01 59	.....
	81 47 30	.....	47 23	47 24	.....
Hip, Table, Notch	76 52 07	.....	51 39	51 33	.....
Notch, Table, Ballenas	44 18 00	.....	18 30	18 36	.....
	121 10 07	.....	10 09	10 09	.....
Table, Ballenas, Notch	49 22 00	.....	20 59	20 47	.....
Ballenas, Notch, Table	86 20 00	.....	20 31	20 37	.....
Notch, Table, Ballenas	44 18 00	.....	18 30	18 36	.....
	180 00 00	.....	00 00	00 00	.....
Ballenas, Notch, Hip	107 41 30	.....	41 36	41 41	.....
Notch, Hip, Ballenas	34 45 30	.....	45 27	45 25	.....
Hip, Ballenas, Notch	37 33 00	.....	32 57	32 54	.....
	.....	.....	.....	.....	.....
Notch, Hip, Table	81 47 30	47 05	47 11	47 23	.....
Hip, Table, Notch	76 52 07	51 42	51 39	51 33	.....
Table, Notch, Hip	21 21 38	21 13	21 10	21 04	.....
	.....	.....	.....	.....	.....
Hip, Table, Ballenas	121 10 07	.....	10 14	10 09	.....
Table, Ballenas, Hip	11 47 53	.....	47 50	47 52	.....
Ballenas, Hip, Table	47 02 00	.....	01 56	01 59	.....
	180 00 00	.....	00 00	00 00	.....

QUADRILATERAL No. 18.

TABLE, BALLENAS, HIP, NOTCH.

	Stations.	Letter.	Angle.			Computation.	
Hip.			°	′	″	4.6077822	
S	Table.	L	121	10	09	9.8643609	
	Ballenas.	R	11	47	52	4.7434213	4.7434213
	Hip.	S	47	01	59	9.3108043	9.9322926
			180	00	00	4.0540256	4.6757139
						L S—11,324.67	
						R S=47,392.967	
L R							
Table. Ballenas.							
Notch.						4.6077822	
S	Table.	L	44	18	36	9.9991151	
	Ballenas.	R	49	20	47	4.6086671	4.6086671
	Notch.	S	86	20	37	9.8800484	9.8441916
			180	00	00	4.4887155	4.4528587
						L S=30,811.69	
						R S=28,369.96	
L R							
Table. Ballenas.							
Notch.						4.6757139	
S	Ballenas.	L	37	32	54	9.9789512	
	Hip.	R	34	45	25	4.6967627	4.6967627
	Notch.	S	107	41	41	9.7550482	9.7849242
			180	00	00	4.4527109	4.4816869
						L S=28,360.3	
						R S=30,317.05	
L R							
Ballenas. Hip.							
Hip.						4.4887155	
S	Table.	L	76	51	33	9.9955258	
	Notch.	R	21	21	04	4.4931897	4.4931897
	Hip.	S	81	47	23	9.5611995	9.9884761
			180	00	00	4.0543892	4.4816658
						L S=11,334.16	
						R S=30,315.57	
L R							
Table. Notch.							

SUMMARY.

Table to Hip	=11,324.67	2d Comp.	=11,334.16
Ballenas to Hip	=47,392.967		
Table to Notch	=30,811.69		
Ballenas to Notch	=28,369.96	2d Comp.	=28,360.3
Hip to Notch	=30,317.05	2d Comp.	=30,315.57

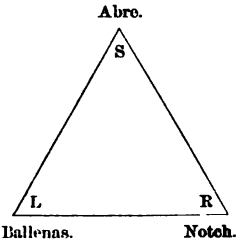
QUADRILATERAL No. 19.

BALLENAS, NOTCH, ABRE, SOUTH BASE.

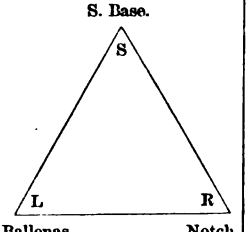
	Measured angles.			1st Adj.		2d Adj.		3d Adj.		4th Adj.	
	°	′	″	′	″	′	″	′	″	′	″
Ballenas, Notch, Abre	159	10	00	10	00	09	55	09	56	09	56
Notch, Ballenas, S. Base	26	28	34	28	34	28	30	28	38	28	38
Ballenas, S. Base, Abre	47	57	30	57	30	57	26	57	25	57	25
S. Base, Abre, Notch	126	23	56	24	14	24	09	24	01	24	01
	360	00	00	00	18	00	00	00	00	.....	
Abre, Notch, S. Base	27	17	48	.....		18	09	18	13	.....	
S. Base, Notch, Ballenas	131	52	12	.....		51	47	51	43	.....	
	159	10	00	.....		09	56	09	56	.....	
Notch, Ballenas, Abre	8	18	34	.....		18	36	18	36	.....	
Abre, Ballenas, S. Base	18	10	00	.....		10	02	10	02	.....	
	26	28	34	.....		28	38	28	38	.....	
Ballenas, S. Base, Notch	21	40	08	.....		39	43	39	39	.....	
Notch, S. Base, Abre	26	17	22	.....		17	42	17	46	.....	
	47	57	30	.....		57	25	57	25	.....	
S. Base, Abre, Ballenas	113	52	30	.....		52	32	52	33	.....	
Ballenas, Abre, Notch	12	31	26	.....		31	29	31	28	.....	
	126	23	56	.....		24	01	24	01	.....	
Ballenas, Notch, Abre	159	10	00	.....		09	55	09	56	.....	
Notch, Abre, Ballenas	12	31	26	.....		31	29	31	28	.....	
Abre, Ballenas, Notch	8	18	34	.....		18	36	18	36	.....	
	180	00	00	.....		00	00	00	00	.....	
Notch, Ballenas, S. Base	26	27	40	.....		28	30	28	38	.....	
Ballenas, S. Base, Notch	21	40	08	.....		39	43	39	39	.....	
S. Base, Notch, Ballenas	131	52	12	.....		51	47	51	43	.....	
	180	00	00	.....		00	00	00	00	.....	
Ballenas, S. Base, Abre	47	57	30	.....		57	26	57	25	.....	
S. Base, Abre, Ballenas	113	52	30	.....		52	32	52	33	.....	
Abre, Ballenas, S. Base	18	10	00	.....		10	02	10	02	.....	
	180	00	00	.....		00	00	00	00	.....	
S. Base, Abre, Notch	126	23	56	24	14	24	09	24	01	.....	
Abre, Notch, S. Base	27	17	48	18	06	18	09	18	13	.....	
Notch, S. Base, Abre	26	17	22	17	40	17	42	17	46	.....	
	179	59	06	00	00	00	00	00	00	.....	

QUADRILATERAL No. 19.

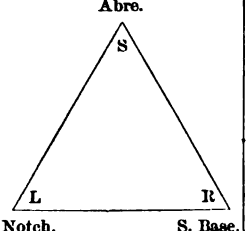
BALLENAS, NOTCH, ABRE, SOUTH BASE.



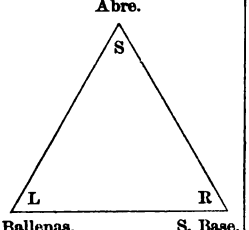
Stations.	Letter.	Angle.	Computation.	
		o ′ ″	4.4527848	
Ballenas.	L	8 18 36	9.3361716	
Notch.	R	159 09 56	5.1166132	5.1166132
Abre.	S	12 31 28	9.5510459	9.1599548
		180 00 00	4.6676591	4.2765680
			L S = 46,522.074	
			R S = 18,904.62	



Stations.	Letter.	Angle.	Computation.	
			4.4527848	
Ballenas.	L	26 28 38	9.5671576	
Notch.	R	131 51 43	4.8856272	4.8856272
S. Base.	S	29 39 39	9.8720135	9.6491809
		180 00 00	4.7576407	4.5348081
			L S = 57,232.263	
			R S = 34,261.643	



Stations.	Letter.	Angle.	Computation.	
			4.5348081	
Notch.	L	27 18 13	9.9057370	
S. Base.	R	26 17 46	4.6290711	4.6290711
Abre.	S	126 24 01	9.6464139	9.6615340
		180 00 00	4.2754850	4.2906051
			L S = 18,857.54	
			R S = 19,525.632	



Stations.	Letter.	Angle.	Computation.	
			4.7576407	
Ballenas.	L	18 10 02	9.9611480	
S. Base.	R	47 57 25	4.7964927	4.7964927
Abre.	S	113 52 33	9.8707794	9.4938641
		180 00 00	4.6672721	4.2903568
			L S = 46,480.	
			R S = 19,514.47	

SUMMARY.

Ballenas to Abre	= 46,522.074	2d Comp. = 46,480.
Notch to Abre	= 18,904.62	2d Comp. = 18,857.54
Ballenas to S. Base	= 57,232.263	
Notch to S. Base	= 34,261.643	
Abre to S. Base	= 19,525.632	2d Comp. = 19,514.47

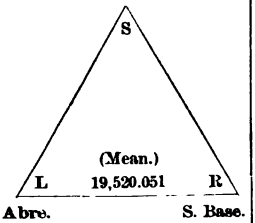
QUADRILATERAL No. 20.

ABRE, SAGE, NORTH BASE, SOUTH BASE.

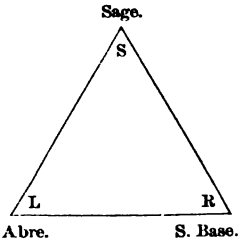
	Measured angles.			1st Adj.		2d Adj.		3d Adj.
	°	′	″	′	″	′	″	
Abre, Sage, N. Base	140	52	17	52	18	52	18	
Sage, N. Base, S. Base	137	26	43	26	44	26	44	
N. Base, S. Base, Abre	60	35	30	35	30	35	31	
S. Base, Abre, Sage	21	05	27	05	28	05	28	
	359	59	57	00	00	00	01	
Abre, Sage, S. Base	117	33	56	33	56			
S. Base, Sage, N. Base	23	18	21	18	22			
	140	52	17	52	18			
Sage, N. Base, Abre	31	12	58	12	58			
Abre, N. Base, S. Base	106	13	45	13	46			
	137	26	43	26	44			
N. Base, S. Base, Sage	19	14	53	14	54			
Sage, S. Base, Abre	41	20	37	20	37			
	60	35	30	35	31			
S. Base, Abre, N. Base	13	10	42	10	43			
N. Base, Abre, Sage	07	54	45	54	45			
	21	05	27	05	28			
Abre, Sage, N. Base	140	52	17	52	17			
Sage, N. Base, Abre	31	12	58	12	58			
N. Base, Abre, Sage	7	54	45	54	45			
	180	00	00	00	00			
Sage, N. Base, S. Base	137	26	43	26	44			
N. Base, S. Base, Sage	19	14	53	14	54			
S. Base, Sage, N. Base	23	18	21	18	22			
	179	59	57	00	00			
N. Base, S. Base, Abre	60	35	30	35	31			
S. Base, Abre, N. Base	13	10	42	10	43			
Abre, N. Base, S. Base	106	13	45	13	46			
	179	59	57	00	00			
S. Base, Abre, Sage	21	05	27	05	27			
Abre, Sage, S. Base	117	33	56	33	56			
Sage, S. Base, Abre	41	20	37	20	37			
	180	00	00	00	00			

QUADRILATERAL No. 20.

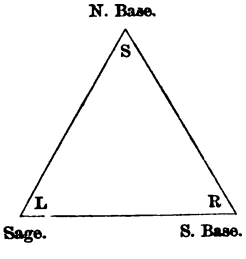
ABRE, SAGE, NORTH BASE, SOUTH BASE.



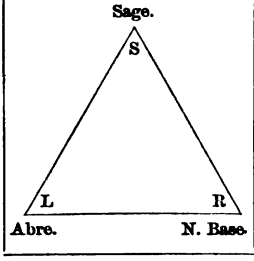
Stations.	Letter.	Angle.	Computation.	
		° ′ ″	4.2904809	
Abre.	L	13 10 43	9.9823391	
S. Base.	R	60 35 31	4.3081418	4.3081418
N. Base.	S	106 13 46	9.9400904	9.3579109
		180 00 00	4.2482322	3.6660527
			L S = 17,710.557	
			R S = 4,635.032	



Stations.	Letter.	Angle.	Computation.	
			4.2904809	
Abre.	L	21 05 27	9.9476699	
S. Base.	R	41 20 37	4.3428110	4.3428110
Sage.	S	117 33 56	9.8199210	9.5561185
		180 00 00	4.1628900	3.8989295
			L S = 14,550.91	
			R S = 7.923.73	



Stations.	Letter.	Angle.	Computation.	
			3.8989295	
Sage.	L	23 18 22	9.8301334	
S. Base.	R	19 14 54	4.0687961	4.0687961
N. Base.	S	137 26 44	9.5180704	9.5973040
		180 00 00	3.5868665	3.6661001
			L S = 3,862.482	
			R S = 4,635.537	



Stations.	Letter.	Angle.	Computation.	
			4.2482322	
Abre.	L	7 54 45	9.8000728	
N. Base.	R	31 12 58	4.4481594	4.4481594
Sage.	S	140 52 17	9.7145539	9.1388097
		180 00 00	4.1627133	3.5869691
			L S = 14,545.	
			R S = 3,863.4	

SUMMARY.

Abre to N. Base	= 17,710.557	
S. Base to N. Base	= 4,635.032	2d Comp. = 4,635.537
Abre to Sage	= 14,550.91	2d Comp. = 14,545.
S. Base to Sage	= 7,923.73	
N. Base to Sage	= 3,862.482	2d Comp. = 3,863.4

QUADRILATERAL No. 16.

SAGE, NORTH BASE, SOUTH BASE, DICK.

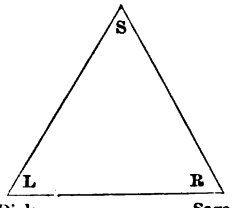
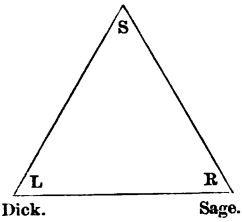
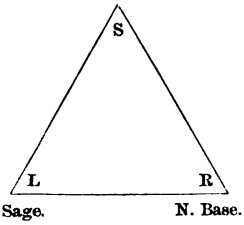
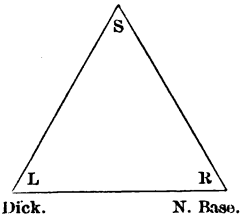
NOTE.—See also quadrilateral 21.

	Measured angles.	1st Adj.	2d Adj.	3d Adj.
	° ′ ″	′ ″	′ ″	′ ″
Sage, N. Base, S. Base	137 26 05	26 17	26 24	26 20
N. Base, S. Base, Dick	80 56 05	56 17	56 20	56 16
S. Base, Dick, Sage	74 06 22	06 33	06 32	06 29
Dick, Sage, N. Base	67 30 42	30 53	30 58	30 55
	359 59 14	00 00	00 14	00 00
Sage, N. Base, Dick	80 46 45	47 08	47 13	.....
Dick, N. Base, S. Base	56 39 20	39 16	39 08	.....
	137 26 05	26 24	26 21	.....
N. Base, S. Base, Sage	19 14 53	15 14	15 17	.....
Sage, S. Base, Dick	61 41 12	41 06	40 59	.....
	80 56 05	56 20	56 16	.....
S. Base, Dick, N. Base	42 24 48	24 44	24 36	.....
N. Base, Dick, Sage	31 41 26	41 48	41 52	.....
	74 06 14	06 32	06 28	.....
Dick, Sage, S. Base	44 12 43	12 38	12 32	.....
S. Base, Sage, N. Base	23 18 00	18 20	18 23	.....
	67 30 43	30 58	30 55	.....
Sage, N. Base, S. Base	137 26 05	26 26	26 20	.....
N. Base, S. Base, Sage	19 14 53	15 14	15 17	.....
S. Base, Sage, N. Base	23 18 00	18 20	18 23	.....
	179 58 58	00 00	00 00	.....
N. Base, S. Base, Dick	80 56 05	56 00	56 16	.....
S. Base, Dick, N. Base	42 24 48	24 44	24 36	.....
Dick, N. Base, S. Base	56 39 20	39 16	39 08	.....
	180 00 13	00 00	00 00	.....
S. Base, Dick, Sage	74 06 22	06 16	06 29	.....
Dick, Sage, S. Base	44 12 43	12 38	12 32	.....
Sage, S. Base, Dick	61 41 12	41 06	40 59	.....
	180 00 17	00 00	00 00	.....
Dick, Sage, N. Base	67 30 42	31 04	30 55	.....
Sage, N. Base, Dick	80 46 45	47 08	47 13	.....
N. Base, Dick, Sage	31 41 26	41 48	41 52	.....
	179 58 53	00 00	00 00	.....

QUADRILATERAL No. 16.

SAGE, NORTH BASE, SOUTH BASE, DICK.

NOTE.—See also quadrilateral 21.

	Stations.	Letter.	Angle.	Computation.	
N. Base.  Dick. Sage.			° ′ ″	3.8591863	
	Dick.	L	31 41 52	9.9943610	
	Sage.	R	67 30 55	3.8648253	3.8648253
	N. Base.	S	80 47 13	9.9056633	9.7205220
			180 00 00	3.8304886	3.5853473
				L S = 6,768.44	
				R S = 3,848.995	
S. Base.  Dick. Sage.				3.8591863	
	Dick.	L	74 06 29	9.9446490	
	Sage.	R	44 12 22	3.9145373	3.9145373
	S. Base.	S	61 40 59	9.8434049	9.9830757
			180 00 00	3.7579422	3.8976130
				L S = 5,727.2	
				R S = 7,899.743	
S. Base.  Sage. N. Base.				3.5853473	
	Sage.	L	23 18 23	9.5182091	
	N. Base.	R	137 26 20	4.0671382	4.0671382
	S. Base.	S	19 15 17	9.8301883	9.5973089
			180 00 00	3.8973265	3.6644471
				L S = 7,894.534	
				R S = 4,617.927	
S. Base.  Dick. N. Base.				3.8304886	
	Dick.	L	42 24 36	9.9945450	
	N. Base.	R	56 39 08	3.8359436	3.8359436
	S. Base.	S	80 56 16	9.9218681	9.8289377
			180 00 00	3.7578117	3.6648813
				L S = 5,725.477	
				R S = 4,622.547	

SUMMARY.

Dick to N. Base	= 6,768.44	
Sage to N. Base	= 3,848.995	
Dick to S. Base	= 5,727.2	2d Comp. = 5,725.477
Sage to S. Base	= 7,899.743	2d Comp. = 7,894.534
N. Base to S. Base	= 4,617.927	2d Comp. = 4,622.547

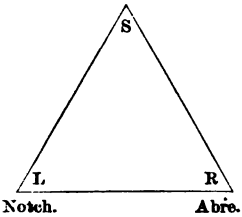
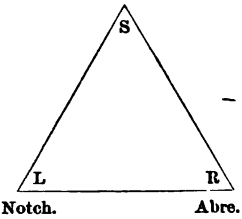
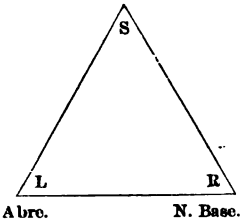
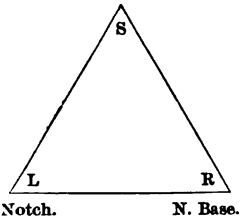
QUADRILATERAL No. 17.

NOTCH, NORTH BASE, SOUTH BASE, ABRE.

	Measured angles.			1st Adj.		2d Adj.		3d Adj.	
	°	′	″	′	″	′	″	′	″
Notch, N. Base, S. Base	140	48	00	48	04	48	02	48	07
N. Base, S. Base, Abre	60	35	30	35	31	35	30	35	32
S. Base, Abre, Notch	126	25	00	24	56	24	54	24	49
Abre, Notch, N. Base	32	11	30	11	35	11	34	11	32
	360	00	00	00	06	00	00	00	00
Notch, N. Base, Abre	34	34	15	34	20	34	21	.....	
Abre, N. Base, S. Base	106	13	45	13	47	13	46	.....	
	140	48	00	48	07	48	07	.....	
N. Base, S. Base, Notch	34	18	08	18	12	18	09	.....	
Notch, S. Base, Abre	26	17	22	17	20	17	22	.....	
	60	35	30	35	32	35	31	.....	
S. Base, Abre, N. Base	13	10	42	10	43	10	42	.....	
N. Base, Abre, Notch	113	14	00	14	06	14	07	.....	
	126	24	42	24	49	24	49	.....	
Abre, Notch, S. Base	27	17	48	17	46	17	49	.....	
S. Base, Notch, N. Base	4	53	42	53	46	53	44	.....	
	32	11	30	11	32	11	33	.....	
Notch, N. Base, Abre	34	34	15	34	20	34	32	34	21
N. Base, Abre, Notch	113	14	00	14	05	14	06	14	07
Abre, Notch, N. Base	32	11	30	11	35	11	34	11	32
	179	59	45	00	00	00	00	00	00
N. Base, S. Base, Abre	60	35	30	35	31	35	30	35	32
S. Base, Abre, N. Base	13	10	42	10	43	10	43	10	42
Abre, N. Base, S. Base	106	13	45	13	46	13	47	13	46
	179	59	57	00	00	00	00	00	00
S. Base, Abre, Notch	126	25	00	24	56	24	54	24	49
Abre, Notch, S. Base	27	17	48	17	45	17	46	17	49
Notch, S. Base, Abre	26	17	22	17	19	17	20	17	22
	180	00	10	00	00	00	00	00	00
Notch, N. Base, S. Base	140	48	00	48	04	48	02	48	07
N. Base, S. Base, Notch	34	18	08	18	11	18	12	18	09
S. Base, Notch, N. Base	4	53	42	53	45	53	46	53	44
	179	59	50	00	00	00	00	00	00

QUADRILATERAL No. 17.

NOTCH, NORTH BASE, SOUTH BASE, ABRE.

	Stations.	Letter.	Angle.	Computation.	
N. Base.  Notch. Abre.			o ' "	4.2747457	
	Notch.	L	32 11 32	9.7538265	
	Abre.	R	113 14 07	4.5208192	4.5208192
	N. Base.	S	34 34 21	9.9632647	9.7265328
			180 00 00	4.4840839	4.2473520
				L S = 30,484.8	
				R S = 17,674.3	
S. Base.  Notch. Abre.				4.2747457	
	Notch.	L	27 17 49	9.6463116	
	Abre.	R	126 24 49	4.6284341	4.6284341
	S. Base.	S	26 17 22	9.9056625	9.6614361
			180 00 00	4.5340966	4.2898702
				L S = 34,205.55	
				R S = 19,492.57	
S. Base.  Abre. N. Base.				4.2473520	
	Abre.	L	13 10 42	9.9400916	
	N. Base.	R	106 13 46	4.3072604	4.3072604
	S. Base.	S	60 35 32	9.9823391	9.3579019
			180 00 00	4.2895995	3.6651623
				L S = 19,480.47	
				R S = 4,625.538	
S. Base.  Notch. N. Base.				4.1840839	
	Notch.	L	4 53 44	9.7509418	
	N. Base.	R	140 48 07	4.7331421	4.7331421
	S. Base.	S	34 19 09	9.8007191	8.9311508
			180 00 00	4.5338612	3.6642929
				L S = 34,187	
				R S = 4,616.288	

SUMMARY.

Notch to N. Base	= 30,484.8	
Abre to N. Base	= 17,674.3	
Notch to S. Base	= 34,205.55	2d Comp. = 34,187
Abre to S. Base	= 19,492.57	2d Comp. = 19,480.47
N. Base to S. Base	= 4,625.538	2d Comp. = 4,616.288

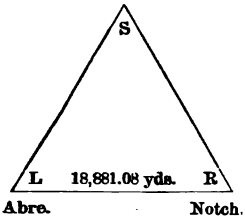
QUADRILATERAL No. 23.

ABRE, NOTCH, DISH, SOUTH BASE.

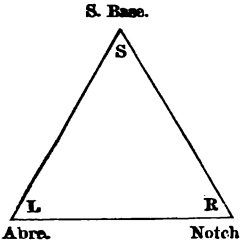
	Measured angles.	1st Adj.	2d Adj.	3d Adj.	4th Adj.
	° ′ ″	′ ″	′ ″	′ ″	′ ″
Abre, Notch, Dish	87 07 00	07 00	07 02	07 01	07 02
Notch, Dish, S. Base	93 30 48	30 48	30 48	30 47	30 46
Dish, S. Base, Abre	52 57 30	57 30	57 33	57 32	57 31
S. Base, Abre, Notch	126 24 42	24 42	24 42	24 40	24 41
	360 00 00	00 00	00 05	00 00	00 00
Abre, Notch, S. Base	27 17 48	17 50	17 53		
S. Base, Notch, Dish	59 49 12	49 12	49 09		
	87 07 00	7 02	7 02		
Notch, Dish, Abre	52 51 15	51 15	51 14		
Abre, Dish, S. Base	40 39 33	39 33	39 32		
	93 30 48	30 48	30 46		
Dish, S. Base, Notch	26 40 08	40 08	40 04		
Notch, S. Base, Abre	26 17 22	17 25	17 27		
	52 57 30	57 33	57 31		
S. Base, Abre, Dish	86 22 57	22 57	22 56		
Dish, Abre, Notch	40 01 45	01 45	01 45		
	126 24 42	24 42	24 41		
Abre, Notch, Dish	87 07 00	7 00	7 01	7 02	
Notch, Dish, Abre	52 51 15	51 15	51 14	51 13	
Dish, Abre, Notch	40 01 45	01 45	01 45	01 45	
	180 00 00	00 00	00 00	00 00	
Notch, Dish, S. Base	93 30 40	30 40	30 47	30 46	
Dish, S. Base, Notch	26 40 08	40 08	40 04	40 05	
S. Base, Notch, Dish	59 49 12	49 12	49 09	49 09	
	180 00 00	00 00	00 00	00 00	
Dish, S. Base, Abre	52 57 30	57 30	57 32	57 31	
S. Base, Abre, Dish	86 22 57	22 57	22 56	22 57	
Abre, Dish, S. Base	40 39 33	39 33	39 32	39 32	
	180 00 00	00 00	00 00	00 00	
S. Base, Abre, Notch	126 24 42	24 45	24 40	24 41	
Abre, Notch, S. Base	27 17 48	17 50	17 53	17 52	
Notch, S. Base, Abre	26 17 22	17 25	17 27	17 27	
	179 79 52	00 00	00 00	00 00	

QUADRILATERAL No. 23.

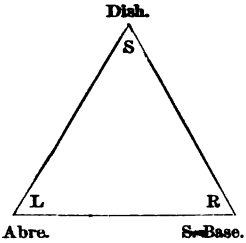
ABRE, NOTCH, DISH, SOUTH BASE.



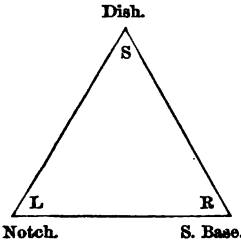
Stations.	Letter.	Angle.			Computation.	
		°	′	″	4.2760258	
Abre.	L	40	01	45	9.9015103	
Notch.	R	87	07	02	4.3745165	4.3745165
Dish.	S	52	51	13	9.9994500	9.8083308
		180	00	00	4.3739665	4.1828473
					L S=23,657.37	
					R S=15,235.17	



Stations.	Letter.	Angle.			Computation.	
					4.2760258	
Abre.	L	126	24	41	9.6463329	
Notch.	R	27	17	52	4.6296939	4.6296939
S. Base.	S	26	17	27	9.6614484	9.9056749
		180	00	00	4.2911423	4.5353688
					L S=19,549.80	
					R S=34,305.9	



Stations.	Letter.	Angle.			Computation.	
					4.2911423	
Abre.	L	86	22	57	9.8139506	
S. Base.	R	52	57	31	4.4771917	4.4771917
Dish.	S	40	39	32	9.9021120	9.9991338
		180	00	00	4.3793037	4.4763255
					L S=23,949.9	
					R S=29,945.1	



Stations.	Letter.	Angle.			Computation.	
					4.5353688	
Notch.	L	59	49	09	9.9991832	
S. Base.	R	26	40	05	4.5361856	4.5361856
Dish.	S	93	30	46	9.6520731	9.9367364
		180	00	00	4.1882587	4.4729220
					L S=15,426.2	
					R S=29,711.33	

SUMMARY.

Abre to Dish	=23,657.37	2d Comp. =23,949.9	Mean=23,803.64
Notch to Dish	=15,235.0	2d Comp. =15,426.2	Mean=15,330.1
Abre to S. Base	=19,549.85		
Notch to S. Base	=34,305.9		
Dish to S. Base	=29,945.1	2d Comp. =29,711.33	Mean=29,828.21

The latitude, longitude, and reverse azimuth were then computed for each station of the main triangulation according to the following formulæ:

$$-dL=K\cos Z.B+K^2\sin^2 Z.C+\delta L^2 D-hK^2\sin^2 Z.E$$
$$-\delta L=K\cos Z.B+K^2\sin^2 Z.C-hK^2\sin^2 Z.E.....$$

$$dM=\frac{K\sin Z}{N'\cos L'\ \text{arc}\ 1''}=\frac{A'.K\sin Z}{\cos L'}$$

$$-dZ=dM\frac{\sin\lambda}{\cos\frac{1}{2}dL}$$

$$Z'=Z+180^\circ+dZ$$

In which dL represents the difference of latitude between two stations.

K, the length of the line joining them.

Z, the azimuth of station whose geographic coördinates are unknown from the station whose geographic coördinates are known.

Z′, the reverse azimuth.

A, A′, B, C, D, and E, constants which are tabulated in Coast and Geodetic Survey Report for 1875, p. 323, *et seq.*, and F, a coefficient which is tabulated in the same report for referring values of dZ from Bessel's to Clark's spheroid.

N′, the normal radius of curvature of the terrestrial spheroid at the station whose geopraphic coördinates are unknown.

$$h=\frac{K}{R\ \text{arc}\ 1''}\cos Z=K.B\cos Z$$

$$L'=L\pm dL$$

dM, the meridian distance between the station whose geographic coördinates are unknown and that whose geographic coördinates are known.

and λ, the middle latitude between the two stations under consideration.

The computation of the latitudes, longitudes, and azimuths of the stations of the main triangulation.

		°	′	″
Z	Obs. Spot to Jack	130	45	16
L	Jack to Yellow	90	15	00
Z	Obs. Spot to Yellow	221	00	16
dZ		+		45.64
180		180	00	00
Z′	Yellow to Obs. Spot	41	01	01.64

	°	′	″			°	′	″
L	27	38	54.875	Obs. Spot	M	114	51	52.523
dL	+ 1		40.657	4,105.57 meters	dM		1	38.309
L′	27	40	35.522	Yellow	M′	114	50	14.214

K	3.6133734	K²	7.22675			h	2.0029
cos Z	—9.8777506	sin² Z	9.63396	(CL²)	4.0058	K² sin² Z	6.8607
B	8.5117283	C	1.12490	D	2.3070	E	5.8727
h	—2.0028503		7.98561		6.3428		4.7363
	″						
1st Term	—100.658	3d Term	0.000			dM²	—5.978
2d Term	0.001	4th Term	0.000			F	7.853
	—100.657		0.000				—3.831
3d and 4th Terms	0.000						
—dL	—100.657						
	° ′ ″			Arg.		dM	—1.9925952
λ	27 39 45.198	K	3.6133734	K	0.0000	sin λ	9.666764
		sin Z	—9.8169816	dM	0.0000	cos ½ dL ar. co.	0.000000
		A′	8.5094104	Corr.	0.0000		—1.659359
		cos L′ ar. co.	0.0527703				
			—1.9925952				
			″				″
		dM	— 98.309			—dZ	—45.64
						2d Term	00

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Obs. Spot to Jack	130	45	16
L	Jack to East Base	156	29	30
Z	Obs. Spot to East Base	287	14	46
dZ		+		59.52
180		180	00	00
Z′	East Base to Obs. Spot	107	15	45.52

	°	′	″			°	′	″
L	27	38	54.875	Obs. Spot	M	114	51	52.523
dL			−35.483	3,682.20 meters	dM	−	02	08.280
L′	27	38	19.392	East Base	M′	114	49	44.243

K		3.5661075	K^2	7.1322150			h	1.5498
cos Z		+9.4719907	$\sin^2 Z$	9.9600432	(δL^2)	3.1000	$K^2 \sin^2 Z$	7.0922582
B		8.5117263	C	1.12490	D	2.3070	E	5.8727
h		1.5498245		8.21715		5.4070		4.5147
		″						
1st Term		+35.467	3d Term	0.0000			dM^2	−6.324
2d Term		+ .016	4th Term	0.0000			F	7.853
		35.483		0.0000				−4.177
3d and 4th Terms		0.000						
−dL		35.483						
	°	′	″		Arg.		dM	−2.108159
λ	27	38	37.133	K	3.5661075	K	−0.0000	sin λ	9.666491
				sin Z	−9.9800216	dM	+0.0000	cos ½ dL ar. co.	0.000000
				A′	8.5094101	Corr.	0.0000		1.774650
				cos L′ ar. co.	0.0526200				
					−2.1081592				
					″				″
				dM	−128.280			−dZ	−59.518
								2d Term	0.000
									59.518

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Obs. Spot to Jack	130	45	16
L	Jack to West Base	187	42	00
Z	Obs. Spot to West Base	318	27	16
dZ	γ			11.80
180		180	00	00.00
Z′	West Base to Obs. Spot	138	27	27.8

	°	′	″			°	′	″
L	27	38	54.875	Obs. Spot	M	114	51	52.523
dL	—		25.551	1,050.81 meters	dM	—		25.423
L′	27	38	29.324	West Base	M′	114	51	27.100

K	3.0215242	K^2	6.0430584			h	1.4074
cos Z	+9.8741654	$\sin^2 Z$	9.6433192	(δL^2)	2.8148	$K^2 \sin^2 Z$	5.6863576
B	8.5117263	C	1.12490	D	2.3070	E	5.8727
h	1.4074159		6.81128		5.1218		2.9664
	″					dM^2	—4.215
1st Term	25.551	3d Term	0.000			F	7.853
2d Term	0.000	—4th Term	0.000				—2.068
	25.551		0.000				
3d and 4th Terms	0.000						
—dL	25.551						
	° ′ ″			Arg.		dM	—1.4052198
λ	27 38 42.099	K	3.0215242	K	0.0000	$\sin \lambda$	9.6665106
		$\sin Z$	—9.8216546	dM	0.0000	$\cos \frac{1}{2}$dL ar. co.	0.0000
		A′	8.5094100	Corr.	0.0000		—1.0717304
		$\cos L'$ ar. co.	0.0526310				
			—1.4052198				
			″				″
		dM	—25.423			—dZ 2d Term	—11.796

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Yellow to Obs. Spot	41 01 01.64
L	Obs. Spot to Mist	5 11 01
Z	Yellow to Mist	46 12 02.64
dZ		— 54.44
180		180 00 00
Z′	Mist to Yellow	226 11 08.20

	° ′ ″			° ′ ″
L	27 40 35.522	Yellow	M	114 50 14.214
dL	— 1 40.147	4,453.09 meters	dM	1 57.254
L′	27 38 55.375	Mist	M′	114 52 11.468

K	3.6486611	K^2	7.29732			h	2.0006
cos Z	9.8401902	$\sin^2 Z$	9.71679	(dL^2)	4.0013	$K^2 \sin^2 Z$	7.0141
B	8.5117244	C	1.12541	D	2.3073	E	5.8732
h	2.0005757		8.13952		6.3086		4.8879
	″					dM^2	6.207
1st Term	100.133	3d Term	0.000			F	7.853
2d Term	.014	—4th Term	0.000				4.060
	100.147		0.000				
3d and 4th Terms	0.000						
—dL	100.147						
	° ′ ″			Arg.		dM	2.0691287
λ	27 39 45.456	K	3.6486611	K	0.0000	$\sin \lambda$	9.6667654
		sin Z	9.8583981	dM	0.0000	$\cos \frac{1}{2}$dL ar. co.	0.0000000
		A′	8.5094098	Corr.	0.0000		1.7358941
		cos L′ ar. co.	0.0526597				
			2.0691287				
			″				″
		dM	117.254			—dZ	54.437
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Yellow to Obs. Spot	41 01 01.64
L	Obs. Spot to Jack	59 11 52
Z	Yellow to Jack	100 12 53.64
dZ		— 2 14.838
180		180 00 00
Z′	Jack to Yellow	280 10 38.802

	′	″			°	′	″
L	27	40 35.522	Yellow	M	114	50	14.214
dL	+	46.474	8,080.93 meters	dM		4	50.237
L′	27	41 21.996	Jack	M′	114	55	04.451

K	3.9074614	K²	7.81492			h	−1.6680
cos Z	−9.2488083	sin² Z	9.98612	(δL²)	3.3344	K² sin² Z	7.80104
B	8.5117244	C	1.12541	D	2.3073	E	5.8732
h	−1.6679941		8.92645		5.6417		5.3422
	″						
1st Term	−46.558						
2d Term	+ .084	3d Term	0.000			dM²	7.3882596
	−46.474	−4th Term	0.000			F	7.853
3d and 4th Terms	0.000		0.000				5.241
dL	−46.474						
	° ′ ″			Arg.		dM	2.462753
γ	27 40 58.761	K	3.9074614	K	−1	sin λ	9.667060
		sin Z	9.9930611	dM	+2	cos ½dL ar. co.	0.0000
		A′	8.5094090	Corr.	+1		2.129813
		cos L′ ar. co.	0.0528216				
			2.4627532				
			″				″
		dM	290.237			−dZ	134.838
						2d Term	0.000

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Yellow to Mist	46	12	02.64
L	Mist to Ridge	109	01	58.03
Z	Yellow to Ridge	155	14	00.64
dZ		−	1	42.23
180		180	00	00
Z′	Ridge to Yellow	335	12	18.41

	°	′	″			°	′	″
L	27	40	35.522	Yellow	M	114	50	14.214
dL	+	7	03.418	14,354.9 meters	dM	+	3	39.674
L′	27	47	38.940	Ridge	M′	114	53	53.888

K	4.1570012	K^2	8.3140024			h	−2.6268
cos Z	−9.9580967	$\sin^2 Z$	9.24426	(δL^2)	5.2535	$K^2 \sin^2 Z$	7.5583
B	8.5117244	C	1.12541	D	2.3073	E	5.8732
h	−2.6268223		8.68367		7.7608		−6.0583
	″					dM^2	
1st Term	−423.470	3d Term	+0.004			F	
2d Term	+ .048	4th Term	0.000				
	−423.422		+ .004				
3d and 4th Terms	+ .004						
−dL =	−423.418			Arg.		dM	+2.341779
	° ′ ″	K	4.1570012	K	−4	sin λ	9.667815
λ	27 44 07.231	sin Z	9.6221322	dM	+1	$\cos \frac{1}{2}$dL ar. co.	0.000000
		A′	8.5094068	Corr.	−3		2.009594
		cos L′ ar. co.	0.0532390				
			2.3417792				
			− 3				
			+2.3417789				
			″				″
		dM	219.674			−dZ	+102.232
						2d Term	0.000

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Yellow to Obs. Spot	41	01	01.64
L	Obs. Spot to West Base	13	48	07
Z	Yellow to West Base	27	12	54.64
dZ		—		33.83
180		180	00	00
Z′	West Base to Yellow	207	12	20.81

	°	′	″			°	′	″
L	27	40	35.522	Yellow	M	114	50	14.214
dL	—	2	06.119	4,776.56 meters	dM	+	1	12.869
L′	27	38	29.403	West Base	M′	114	51	27.083

K		3.6402690	K^2	7.280538			h	
cos Z		9.9490459	$\sin^2 Z$	9.320466	(δL^2)		$K^2 S$	
B		8.5117242	C	1.12541	D		E	
h		2.1010391		7.72641				
		″						
1st Term		+126.194	3d Term	0.000			dM^2	0.000
2d Term		+ .005	—4th Term	0.000			F	0.000
		126.199		0.000				
3d and 4th Terms		0.000						
—dL		126.199						
	°	′	″		Arg.		dM	1.862543
λ	27	39	32.462	K	3.6402690	K	sin λ	9.666713
				sin Z	9.6602330	dM	$\cos\frac{1}{2}$ dL ar. co.	0.000000
				A′	8.5094100	Corr.		1.529256
				cos L′ ar. co.	0.0526311			
					1.8625431			
					″			″
				dM	+72.869		—dZ	+33.83
							2d Term	

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Yellow to Obs. Spot	41 01 01.64
L	Obs. Spot to East Base	52 07 21
Z	Yellow to East Base	348 53 40.64
dZ		+ 13.92
180		180 00 00
Z′	East Base to Yellow	168 53 54.56

L	27	40	35.522	Yellow	M	114	50	14.214
dL	—	2	16.108	4,668.6 meters	dM	—		29.995
L′	27	38	19.414	East Base	M′	114	49	44.219

K			3.6303403	K^2	7.26068			h	
cos Z			+9.9917905	$\sin^2 Z$	9.56938	(dL^2)		$K^2 \sin^2 Z$	
B			8.5117244	C	1.12541	D		E	
h			2.1338552		7.95547				
			″						
1st Term			+136.099	3d Term				dM^2	
2d Term			+ .009	4th Term				F	
			136.108						
3d and 4th Terms									
—dL			+136.108						
	°	′	″			Arg.		dM	—1.477059
λ	27	39	27.468	K	3.6303403	K		$\sin \lambda$	9.666693
				$\sin Z$	—9.2846881	dM		$\cos \frac{1}{2}$dL ar.co.	0.000000
				A′	8.5094101	Corr.			1.143752
				cos L′ ar.co.	0.0526201				
					1.4770586				
					″				″
				dM	—29.995			—dZ	—13.92
								2d Term	

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	East Base to Obs. Spot	107	15	45.52
L	Obs. Spot to West Base	11	04	16
Z	East Base to West Base	96	11	29.52
dZ		−		47.72
180		180	00	00
Z′	West Base to East Base	276	10	41.80

L	27	38	19.453	East Base			M	114	49	44.231
dL	+		09.927	2,836.30 meters			dM	+	1	42.861
L′	27	38	29.330	West Base			M′	114	51	27.092

K			3.4527524	K^2	6.90550			h		
cos Z			9.0328299	$\sin^2 Z$	9.99492	(δL^2)		$K^2 \sin^2 Z$		
B			8.5117266	C	1.12472	D		E		
h			0.9973089		8.02514					
			″							
1st Term			−9.938	3d Term				dM^2		
2d Term			+ .011	4th Term				F		
			−9.927							
3d and 4th Terms										
−dL			−9.927							
	°	′	″			Arg.		dM		2.012251
λ	27	38	24.366	K	3.4527524	K		$\sin \lambda$		9.666440
				$\sin Z$	9.9974593	dM		$\cos \frac{1}{2} dL$ ar.co.		0.000000
				A′	8.5094100	Corr.				1.678693
				cos L′ ar.co.	0.0526310					
					2.0122527					
					″					″
				dM	+102.861			−dZ		+47.72
								2d Term		

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	East Base to Yellow	168	53	54.56
L	Yellow to Mist	63	33	26
Z	East Base to Mist	105	20	28.56
dZ		—	1	08.31
180		180	00	00
Z′	Mist to East Base	285	19	20.25

	°	′	″			°	′	″
L	27	38	19.403	East Base	M	114	49	44.231
dL	+		35.953	4,185.45 meters	dM	+	2	27.589
L′	27	38	55.356	Mist	M′	114	52	11.820

K		3.6217421	K^2	7.24348			h	
cos Z		—9.4225368	$\sin^2 Z$	9.96848	(δL^2)		$K^2 \sin^2 Z$	
B		8.5117266	C	1.12472	D		E	
h		—1.5560055		8.33668				
		″						
1st Term		—35.975	3d Term				dM^2	
2d Term		+ .022	4th Term				F	
		—35.953						
3d and 4th Terms								
—dL		—35.953						
	°	′	″		Arg.		dM	2.168054
λ	27	38	37.380	K	3.6217421	K	sin λ	9.666420
				sin Z	9.9842424	dM	$\cos \frac{1}{2}$ dL ar.co.	0.000000
				A′	8.5094098	Corr.		1.834474
				cos L′ ar.co.	0.0526597			
					2.1680540			
					″			″
				dM	+147.589		—dZ	+68.61
							2d Term	

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	East Base to Mist	105	20	28.56
L	Mist to Jack	17	18	37
Z	East Base to Jack	122	39	05.56
dZ		—	2	28.71
180		180	00	00
Z′	Jack to East Base	302	36	36.85

	°	′	″			M	°	′	″
L	27	38	19.403	East Base		M	114	49	44.231
dL	+	3	02.572	10,421.70 meters		dM	+	5	20.232
L′	27	41	21.975	Jack		M′	114	55	04.463

K	4.0179388	K²	8.03587			h	
cos Z	−9.7320143	sin² Z	9.85059	(δL²)	.....	K² sin² Z	.....
B	8.5117266	C	1.12472	D	.....	E	.....
h	2.2616797		9.01118		.....		.....
	″					dM²	.....
1st Term	−182.675	3d Term				F	.....
2d Term	+ .103	4th Term					
	−182.572						
3d and 4th Terms							
−dL	−182.572						
	° ′ ″			Arg.		dM	2.505546
γ	27 39 50.689	K	4.0179388	K	−2	sin λ	9.666786
		sin Z	9.9252953	dM	+2	cos ½dL ar.co.	0.000000
		A′	8.5094090	Corr.	0		2.172232
		cos L′ ar.co.	0.0528215				
			2.5054646				
			″				″
		dM	320.232			−dZ	+148.71
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Mist to Yellow	226	11	08.20
L	Yellow to Jack	92	35	05
Z	Mist to Jack	133	36	03.20
dZ		—	1	20.33
180		180	00	00
Z′	Jack to Mist	313	34	42.87

	°	′	″			°	′	″
L	27	38	55.365	Mist	M	114	52	11.644
dL	+	2	26.618	6,545.38 meters	dM	—	2	52.982
L′	27	41	21.983	Jack	M′	114	55	04.626

K	3.8159349	K²	7.6318698			h	.....
cos Z	9.8386167*n*	sin² Z	9.71967	(δL²)	.....	K² sin² Z	.....
B	8.5117260	C	1.12489	D	.....	E	.....
h	2.1662776		8.47643		.....		.....
	″					dM³	.....
1st Term	—146.648	3d Term				F	.....
2d Term	+ .030	4th Term					
	146.618						
3d and 4th Terms							
—dL	—146.618						
	° ′ ″			Arg.		dM	+2.238001
λ	27 40 08.674	K	3.8159349	K	.....	sin λ	+9.666859
		sin Z	9.8598352	dM	.....	cos ½ dL ar.co.	0.000000
		A′	8.5094090	Corr.	.....		1.50.860
		cos L′ ar.co.	0.0528216				
			2.2380007				
			″				″
		dM	+172.982			—dZ	+80.33
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Mist to Yellow	226	11	08.20
L	Yellow to Ridge	56	03	18
Z	Mist to Ridge	170	07	50.20
dZ		—		47.65
180		180	00	00
Z′	Ridge to Mist	350	07	02.55

	°	′	″			°	′	″
L	27	38	55.365	Mist	M	114	52	11.644
dL	+	8	43.568	16,358.21 meters	dM	+	1	42.423
L′	27	47	38.933	Ridge	M′	114	53	54.067

K	4.2137357	K^2	8.4274714			h	2.7190
cos Z	9.9935249	$\sin^2 Z$	8.46804	(δL^2)	5.4380	$K^2 \sin^2 Z$	6.8955
B	8.5117260	C	1.12489	D	2.3070	E	5.8727
h	2.7189866		8.02040		7.7450		5.4872
	″					dM^2	
1st Term	—523.484	3d Term	.006			F	
2d Term	+ .010	4th Term	.000				
	—523.574						
3d and 4th Terms	+ .006						
—dL	—523.568						
	° ′ ″			Arg.		dM	2.010399
λ	27 43 17.149	K	4.2137357	K	—5	$\sin \lambda$	9.667615
		$\sin Z$	+9.2340178	dM	0	$\cos \frac{1}{2}$dL ar.co.	0.000000
		A′	8.5094068	Corr.	—5		+1.678014
		$\cos L'$ ar.co.	0.0532387				
			2.0103985				
			″				″
		dM	+102.423			—dZ	+47.65
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Jack to Yellow	280	10	38.802
L	Yellow to Ridge	90	43	09
Z	Jack to Ridge	189	27	29.80
dZ		+		32.87
180		180	00	00
Z′	Ridge to Jack	9	28	02.67

	°	′	″			°	′	″
L	27	41	21.985		M	114	55	04.513
dL	+	6	16.957	Jack 11,763.1 meters	dM	—	1	10.613
L′	27	47	38.942	Ridge	M′	114	53	53.900

K	4.0705222	K²	8.14104			h	
cos Z	9.9940555*n*	sin² Z	8.43143	(δL²)	5.1526	K² sin² Z	
B	8.5117233	C	1.12565	D	2.3075	E	
h	2.5763010		7.69812		7.4601		
	″					dM²	5.547
1st Term	—376.965	3d Term	+ .003			F	7.853
2d Term	+ .005	—4th Term					2.306
	—376.960						
3d and 4th Terms	.003						
—dL	—376.957						
	° ′ ″			Arg.		dM	—1.848883
λ	27 44 30.431	K	4.0705222	K	—3	sin λ	+9.667908
		sin Z	9.2157152*n*	dM	+0	cos ½ dL ar.co.	0.000000
		A′	8.5094068	Corr.	—3		1.516791
		cos L′ ar.co.	0.0532390				
			—1.8488832				
			.0000003				
			—1.8488829				
			″				″
		dM	— 70.613			—dZ	—32.87
						2d Term	0.00

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Jack to Yellow	280	10	38.802
L	Yellow to Tail	152	09	09
Z	Jack to Tail	128	01	29.80
dZ		—	2	44.02
180		180	00	00
Z′	Tail to Jack	307	58	45.78

	°	′	″			°	′	″
L	27	41	21.985	Jack	M	114	55	04.513
dL	+	4	05.160	12,256.45 meters	dM	+	5	52.573
L′	27	45	27.145	Tail	M′	115	00	57.086

K	4.0883648	K^2	8.17673			h		—2.3897
cos Z	—9.7895838	$\sin^2 Z$	9.79277	(δL^2)	4.7799	$K^2 \sin^2 Z$		7.9695
B	8.5117233	C	1.12565	D	2.3075	E		5.8734
h	—2.3896719		9.09515		7.0874			—6.2326
	″							
1st Term	—245.285	3d Term	0.000			dM^2		7.642
2d Term	+ .125	4th Term	0.000			F		7.853
	—245.160							5.495
3d and 4th Terms	0.000							
—dL	—245.160			Arg.		dM		2.547250
	° ′ ″			K	—3	sin λ		9.667644
λ	27 43 24.533	K	4.0883648	dM	+3	$\cos \frac{1}{2}$ dL ar. co.		0.000000
		sin Z	9.8963843	Corr.	0			2.214894
		A′	8.5094076					
		cos L′ ar. co.	0.0530928					
			2.5472495					
			″					″
		dM	352.573			—dZ		164.019
						2d Term		.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Jack to Tail	128 01 29.80
L	Tail to Whale	126 12 58
Z	Jack to Whale	254 14 27.80
dZ		+ 5 30.30
180		180 00 00
Z′	Whale to Jack	74 19 58.10

L	27	41	21.985	Jack		M	114	55	04.513
dL	+	2	57.825	20,211.86 meters		dM	−	11	50.222
L′	27	44	19.810	Whale		M′	114	43	14.291

K	4.3056064	K²	8.61121			h	2.2525
cos Z	−9.4339149	sin² Z	9.96672	(δL²)	.....	K² sin² Z	8.5777
B	8.5117233	C	1.12565	D	.....	E	5.8734
h	2.2512446		9.70358		.....		6.7036
	″						
1st Term	−178.330	3d Term	0.0000			dM³	−8.553
2d Term	+ .505	4th Term	0.0000			F	7.853
	−177.825						6.406
3d and 4th Terms	0.000						
−dL	−177.825						
	° ′ ″			Arg.		dM	−2.851394
λ	27 42 50.865	K	4.3056061	K	−8	sin λ	9.667510
		sin Z	−9.9833614	dM	+9	cos ½ dL ar. co.	0.000000
		A′	8.5094080	Corr.	+1		−2.518904
		cos L′ ar. co.	0.0530183				
			−2.8513942				
			″				″
		dM	710.222			−dZ	−330.30
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Jack to Whale	254	14	27.80
L	Whale to Summit	39	28	55
Z	Jack to Summit	293	43	22.80
dZ		+	11	16.03
180		180	00	00
Z′	Summit to Jack	113	54	38.83

	°	′	″				°	′	″
L	27	41	21.985	Jack		M	114	55	04.513
dL	—	9	33.604	43,721.90 meters		dM	—	24	18.680
L′	27	31	48.381	Summit		M′	114	30	45.833

K	4.6406989	K^2	9.28140			h	+2.7562
cos Z	+9.6045666	$\sin^2 Z$	9.92332	(δL^2)	5.5172	$K^2 \sin^2 Z$	9.2050
B	8.5117233	C	1.12565	D	2.3075	E	5.8734
h	2.7569888		0.33037		7.8247		7.8346
	″						
1st Term	+571.464	3d Term	+.007			dM^2	9.492
2d Term	+ 2.140	4th Term	+.007			F	7.853
	573.604						7.345
3d and 4th Terms	0.000						
—dL	573.604						
	° ′ ″			Arg.		dM	—3.163961
λ	27 36 35.183	K	4.6406989	K	−35	$\sin \lambda$	9.606002
		$\sin Z$	−9.9616589	dM	+37	$\cos \frac{1}{2}$ dL ar. co.	0.000000
		A′	8.5094123	Corr.	+ 2		−2.829963
		$\cos L'$ ar. co.	0.0521899				
			−3.1639602				
			″				″
		dM	1458.680			−dZ	−676.03
						2d Term	0.00
							−676.03

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Jack to Whale	254	14	27.80
L	Whale to Noble	54	05	47
Z	Jack to Noble	308	20	14.80
dZ		+	5	58.31
180		180	00	00
Z′	Noble to Jack	128	26	13.11

	°	′	″			°	′	″
L	27	41	21.985	Jack	M	114	55	04.513
dL	—	9	05.600	27,042.16 meters	dM	—	12	53.029
L′	27	32	16.385	Noble	M′	114	42	11.484

K	4.4320413	K²	8.8640826			h	2.7359
cos Z	+9.7925960*n*	sin² Z	+9.78904	(δL^2)	5.4728	K² sin² Z	8.6537
B	8.5117233	C	1.12565	D	2.3075	E	5.8734
h	2.7363606		9.77877		7.7803		7.2630
	″						
1st Term	+544.955	3d Term	0.006			dM^2	8.665
2d Term	+ .601	—4th Term	0.002			F	7.853
	545.556		+0.004				6.518
3d and 4th Terms	+ 0.004						
—dL	+545.600						
	° ′ ″			Arg.		dM	—2.888196
λ	27 36 49.185	K	4.4320413	K	—13	sin λ	9.666058
		sin Z	—9.8945216	dM	+11	cos ½dL ar. co.	0.000000
		A′	8.5094121	Corr.	— 2		—2.554254
		cos L′ ar. co.	0.0522207				
			—2.8881957				
			″				″
		dM	—773.029			—dZ	—358.31
						2d Term	0.00

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Ridge to Jack	9	28	02.67
L	Jack to Tail	61	19	53
Z	Ridge to Tail	70	47	55.67
dZ		—	3	17 84
180		180	00	00
Z′	Tail to Ridge	250	44	37.83

	°	′	″				°	′	″
L	27	47	38.938	Ridge		M	114	53	53.952
dL	—	2	11.714	12,310.36 meters		dM	+	7	04.535
L′	27	45	27.124	Tail		M′	115	00	58.487

K	4.0902709	K^2	8.18054			h		2.1190
cos Z	9.5170461	$\sin^2 Z$	9.95028	(δL^2)	4.2393	$K^2 \sin^2 Z$		8.1308
B	8.5117158	C	1.12757	D	2.3085	E		5.8751
h	2.1190328		9.25839					.....
	″							
1st Term	+131.533	3d Term	.....			dM^2		7.884
2d Term	+ .181	—4th Term	.....			F		.....
	+131.714		.....					.....
3d and 4th Terms	0.000							
—dL	+131.714							
	° ′ ″			Arg.		dM		2.627913
λ	27 46 33.081	K	4.0902709	K	—3	$\sin \lambda$		9.668396
		$\sin Z$	9.9751420	dM	+3	$\cos \frac{1}{2}$ dL ar. co.		0.000000
		A′	8.5094076	Corr.	0			2.296309
		$\cos L'$ ar. co.	0.0530929					
			2.6279134					
			″					″
		dM	+424.535			—dZ		+197.84
						2d Term		.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Ridge to Jack	9 28 02.67
L	Jack to Whale	80 13 13
Z	Ridge to Whale	289 14 49.67
dZ		— 4 57.98
180		180 00 00
Z′	Whale to Ridge	109 09 51.69

	° ′ ″			° ′ ″
L	27 47 38.938	Ridge	M	114 53 53.952
dL	— 3 19.131	18,555.74 meters	dM	— 10 39.625
L′	27 44 19.807	Whale	M′	114 43 14.327

K	4.2684782	K^2	8.53696			h	2.2982
cos Z	9.5180443	$\sin^2 Z$	9.95004	(δL^2)	4.5983	$K^2 \sin^2 Z$	8.4870
B	8.5117158	C	1.12757	D	2.3085	E	5.8751
h	2.2982383		9.61457		6.9068		6.6603
	″						
1st Term	+198.718	3d Term	.....			dM^2	.....
2d Term	+ .412	—4th Term	.....			F	.....
	+199.130		.....				.....
3d and 4th Terms	0.000						
—dL	+199.131						
	° ′ ″			Arg.		dM	2,805925
λ	27 45 59.322	K	4.2684782	K	—6	sin λ	9.668266
		sin Z	9.9750205*n*	dM	+7	$\cos \frac{1}{2}$ dL ar. co.	0.000000
		A′	8.5094080	Corr.	+1		2.474191
		cos L′ ar. co.	0.0530183				
			2.8059251				
			″				″
		dM	—639.625			—dZ	+297.98
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Tail to Jack	307	58	45.78
L	Jack to Whale	33	59	40
Z	Tail to Whale	273	59	05.78
dZ		+	8	15.01
180		180	00	00
Z′	Whale to Tail	94	07	20.79

	°	′	″			°	′	″
L	27	45	27.184	Tail	M	115	00	57.786
dL	—	1	07.039	29,190.26 meters	dM	—	17	43.197
L′	27	44	20.145	Whale	M′	114	43	14.589

K	4.4652380	K^2	8.93048			h	+1.8189
cos Z	+8.8419489	$\sin^2 Z$	9.99790	(δL^2)		$K^2 \sin^2 Z$	.....
B	8.5117190	C	1.12690	D	2.3081	E	5.8745
h	+1.8189059		0.05528				
	″						
1st Term	+65.903	3d Term				dM^2	9.080
2d Term	+ 1.136	—4th Term				F	7.853
	67.039						6.933
3d and 4th Terms	0.000						
—dL	+67.039						
	° ′ ″			Arg.		dM	—3.026614
λ	27 44 53.664	K	4.4652380	K	—15	$\sin \lambda$	+9.668001
		$\sin Z$	—9.9989487	dM	+20	$\cos \frac{1}{2} dL$ ar. co.	0.000000
		A′	8.5094080	Corr.	+ 5		2.694615
		cos L′ ar. co.	0.0530186				
			3.0266133				
			0.0000005				
			—3.0266138				
			″				″
		dM	1,063.197			—dZ	495.01
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Tail to Whale	273 59 05.78
L	Whale to Cerros	119 56 32
Z	Tail to Cerros	154 02 33.78
dZ		— 5 49.29
180		180 00 00
Z′	Cerros to Tail	333 56 44.49

	° ′ ″			° ′ ″
L	27 45 27.184	Tail	M	115 00 57.786
dL	+ 22 36.788	46,469.22 meters	dM	+ 12 25.329
L′	28 08 03.972	Cerros	M′	115 13 23.115

K	4.6671654	K^2	9.33433			h	−3.1327
cos Z	9.9538180n	$\sin^2 Z$	+9.28236	(δL^2)	6.2651	$K^2 \sin^2 Z$	8.6167
B	8.5117190	C	1.12690	D	2.3081	E	5.8745
h	−3.1327024		9.74359		8.5732		−7.0239
	″						
1st Term	−1,357.383	3d Term	+ .037			dM^3	.....
2d Term	+ .554	−4th Term	+ .004			F	.....
	−1,356.829		+ .041				.....
3d and 4th Terms	+ .041						
−dL	−1,356.788						
				Arg.		dM	+2.872349
	° ′ ″	K	4.6671654	K	−39	$\sin \lambda$	+9.670839
λ	27 56 45.578	$\sin Z$	9.6411775	dM	+10	$\cos \frac{1}{2}$ dL ar. co.	0.000002
		A′	8.5093996	Corr.	−29		2.543190
		cos L′ ar. co.	0.0546085				
			2.8723510				
			0.0000029				
			2.8723481				
			″				″
		dM	745.329			−dZ	+349.29
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Tail to Cerros	154	02	33.78
L	Cerros to Natividad	25	55	46
Z	Tail to Natividad	128	06	47.78
dZ		—	5	14.78
180		180	00	00
Z′	Natividad to Tail	308	01	33.00

	°	′	″			M	°	′	″
L	27	45	27.184	Tail		M	115	00	57.786
dL	+	7	49.663	23,445.25 meters		dM	+	11	14.427
L′	27	53	16.847	Natividad		M′	115	12	12.213

K	4.3700549	K^2	8.74011			h		—2.6722
cos Z	9.7904386	$\sin^2 Z$	9.79172	(δL^2)	5.3444	$K^2 \sin^2 Z$		8.5318
B	8.5117190	C	1.12690	D	2.3081	E		5.8745
h	2.6722125		+9.65873		7.6525			—7.0785
	″							
1st Term	—470.124	3d Term	.004			dM^3		.....
2d Term	+ .456	—4th Term	+ .001			F		.....
	—469.668		.005					.....
3d and 4th Terms	+ .005							
—dL	—469.663							
	° ′ ″			Arg.		dM		+2.828935
λ	27 49 22.015	K	4.3700549	K	—10	sin λ		+9.669074
		sin Z	+9.8958609	dM	+ 9	$\cos \frac{1}{2}$ dL ar. co.		0.000000
		A′	8.5094047	Corr.	— 1			2.498009
		cos L′ ar. co.	0.0536148					
			2.8289352					
			″					″
		dM	+674.427			—dZ 2d Term		+314.78

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Whale to Tail	94	07	20.79
L	Tail to Natividad	15	08	52
Z	Whale to Natividad	109	16	12.79
dZ		—	13	30.74
180		180	00	00
Z′	Natividad to Whale	289	02	42.05

	°	′	″			°	′	″
L	27	44	19.921	Whale	M	114	43	14.402
dL	+	8	56.756	50,345.72 meters	dM	+	28	57.570
L′	27	53	16.677	Natividad	M′	115	12	11.972

K	4.7019626	K^2	9.40392			h		−2.7322
cos Z	9.5185452*n*	$\sin^2 Z$	9.94992	(δL^2)	5.4596	$K^2 \sin^2 Z$		9.3538
B	8.5117202	C	1.12655	D	2.3080	E		5.8742
h	−2.7322280		0.48039		7.7676			7.9602
	″							
1st Term	−539.794	3d Term	+.006			dM^2		9.720
2d Term	+ 3.023	−4th Term	+.009			F		7.853
	−536.771		.015					7.573
3d and 4th Terms	+ .015							
−dL	−536.756							
	° ′ ″			Arg.		dM		+3.239942
λ	27 48 48.299	K	4.7019626	K	−45	sin λ		9.668939
		sin Z	+9.9749595	dM	+52	$\cos \frac{1}{2}$dL ar. co.		0.000000
		A′	8.5094047	Corr.	+07			2.908881
		cos L′ ar. co.	.0536148					
			3.2399416					
			.0000007					
			3.2399423					
			″					″
		dM	1737.570			−dZ		+810.74
						2d Term		----------

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Whale to Natividad	109	16	12.79
L	Natividad to Cerros	22	24	04
Z	Whale to Cerros	131	40	16.79
dZ		—	14	07.22
180		180	00	00
Z′	Cerros to Whale	311	26	09.57

	°	′	″			°	′	″
L	27	44	19.921	Whale	M	114	43	14.402
dL	+ 23		43.691	66,066.52 meters	dM	+ 30		08.384
L′	28	08	03.612	Cerros	M′	115	13	22.786

K	4.8199814	K²	9.63996			h		−3.1544
cos Z	9.8227280*n*	sin² Z	9.74661	(δL^2)	6.3129	K² sin² Z		9.3806
B	8.5117202	C	1.12655	D	2.3080	E		5.8742
h	3.1544296		0.51312		+8.6209			−8.4152
	″							
1st Term	−1427.018	3d Term	+.042			dM^2		9.772
2d Term	+ 3.259	−4th Term	+.026			F		7.853
	−1423.759		+.068					7.625
3d and 4th Terms	+ 0.068							
−dL	−1423.691							
	° ′ ″			Arg.		dM		3.257291
λ	27 56 11.766	K	4.8199814	K	−78	sin λ		9.670704
		sin Z	8.5093996	dM	+56	cos ½ dL ar. co.		.000003
		A′	0.0546081	Corr.	−22			2.927998
		cos L′ ar. co.	3.2572928					
			−.0000022					
			3.2572906					
			″					″
		dM	1808.384			−dZ		+847.22
							′	″
						2d Term	14	07.22

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Whale to Cerros	131	40	16.79
L	Cerros to Lagoon Head	94	31	43
Z	Whale to Lagoon Head	226	11	59.79
dZ		+	17	18.34
180		180	00	00
Z′	Lagoon Head to Whale	46	29	18.13

	°	′	″			°	′	″
L	27	44	19.921	Whale	M	114	43	14.402
dL	+ 31		13.262	83,528.80 meters	dM	−	36	51.756
L′	28	15	33.183	Lagoon Head	M′	114	06	22.646

K		4.9218365	K^2	9.84367			h	−3.2738
cos Z		−9.8401963	$\sin^2 Z$	9.71679	(δL^2)	6.5453	$K^2 \sin^2 Z$	9.5605
B		8.5117202	C	1.12655	D	2.3080	E	5.8742
h		3.2737530		0.68701		+8.8533		−8.7085
		″						
1st Term		−1878.248	3d Term	.071			dM^2	−0.034
2d Term		+ 4.864	−4th Term	+.051			F	7.853
		−1873.384		+.122				−7.887
3d and 4th Terms		+ .122						
−dL		−1873.262						
	°	′	″		Arg.		dM	−3.344737
λ	27	59	56.552	K	K	4.9218365	−124	sin λ 9.671596
				sin Z	dM	−9.8583925	+084	$\cos \frac{1}{2}$ dL ar. co. .000004
				A′	Corr.	8.5093968	− 40	3.016337
				cos L′ ar. co.		0.0551155		
						3.3447413		
						− .0000040		
						3.3447373		
						″		″
				dM		−2211.756	−dZ	−1038.33
							2d Term	−0000.01
								−1038.34

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Whale to Jack	74	19	58.10
L	Jack to Noble	78	45	30
Z	Whale to Noble	355	34	28.10
dZ		+		29.13
180		180	00	00
Z′	Noble to Whale	175	34	57.23

	°	′	″			°	′	″
L	27	44	19.921	Whale	M	114	43	14.402
dL	—	12	03.394	22,332.75 meters	dM	—	1	02.803
L′	27	32	16.527	Noble	M′	114	42	11.599

K	4.3489423	K^2	8.69788			h		2.8593
cos Z	+9.9987032	$\sin^2 Z$	7.77482	(δL^3)	5.7187	$K^2 \sin^2 Z$		6.4727
B	8.5117202	C	1.12655	D	2.3080	E		5.8742
h	2.8593657		7.59925		8.0267			5.2062
	″							
1st Term	+723.379	3d Term	+.011			dM^3		.....
2d Term	+ .004	—4th Term	.000			F		.....
	+723.383							.....
3d and 4th Terms	+ .011							
—dL	+723.394							
	° ′ ″			Arg.		dM		—1.797983
λ	27 38 18.224	K	4.3489423	K	—10	sin λ		9.666415
		sin Z	8.8874085n	dM	— 0	$\cos \frac{1}{2}$ dL ar. co.		0.000001
		A′	8.5094121	Corr.	—10			1.464399
		cos L′ ar.co.	0.0522209					
			1.7979838					
			—0.0000010					
			—1.7979828					
			″					″
		dM	62.803			—dZ		—29.13
						2d Term		.00

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Whale to Noble	355 34 28.16
L	Noble to Summit	37 10 02
Z	Whale to Summit	318 24 26.10
dZ		+ 5 46.73
180		180 00 00
Z′	Summit to Whale	138 30 12.83

	° ′ ″			° ′ ″
L	27 44 19.921	Whale	M	114 43 14.402
dL	— 12 31.378	30,901.14 meters	dM	— 12 27.539
L′	27 31 48.543	Summit	M′	114 30 46.863

K	4.4899745	K^2	8.97995			h	+2.8755
cos Z	+9.8738331	$\sin^2 Z$	9.64412	(δL^2)	5.7517	$K^2 \sin^2 Z$	8.6241
B	8.5117202	C	1.12655	D	2.3080	E	5.8742
h	2.8755278		9.75062		8.0597		7.3738
	″						
1st Term	+750.806	3d Term	+ .011			dM^3	.....
2d Term	+ .563	—4th Term	.002			F	.....
	+751.369		+ .009				.....
3d and 4th Terms	+ .009						
—dL	+751.378						
	° ′ ″			Arg.		dM	—2.873634
λ	27 38 04.232	K^2	4.4899745	K	—17	$\sin \lambda$	9.666358
		$\sin^2 Z$	—9.8220579	dM	+10	$\cos \frac{1}{2}$ dL ar. co.	0.000001
		A′	8.5094123	Corr.	— 7		2.539993
		cos L′ ar.co.	0.0521901				
			2.8736348				
			0.0000007				
			2.8736341				
			″				″
		dM	747.539			—dZ	—346.73

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Natividad to Whale	289	02	42.05
L	Whale to Cerros	113	05	53
Z	Natividad to Cerros	175	56	49.05
dZ		—		33.29
180		180	00	00
Z′	Cerros to Natividad	355	56	15.36

		°	′	″				°	′	″
L		27	53	16.762		Natividad	M	115	12	12.092
dL	+		14	46.898		27,369.11	dM	+	1	10.886
L′		28	08	03.660		Cerros	M′	115	13	22.978

K	4.4372607	K²	8.87452			h		2.9479
cos Z	9-9989125n	sin² Z	7.69859	(dL²)	5.8957	K² sin² Z		6.5731
B	8.5117107	C	1.12927	D	2.3095	E		5.8767
h	—2.9478839		7.70238		8.2052			5.3977
	″							
1st Term	—886.919	3d Term	+.016			dM²		4.552
2d Term	+ .005	—4th Term				F		7.854
	—886.914							.....
3d and 4th Terms	+ .016							
—dL	—886.898							
	° ′ ″				Arg.	dM		1.850563
λ	28 00 40.211	K	4.4372607	K	—13	sin λ		9.671769
		sin Z	+8.8492962	dM	+ 0	cos ½ dL ar. co.		0.000001
		A′	8.5093996	Corr.	—13			+1.532333
		cos L′ ar. co.	0.0546081					
			1.8505046					
			—0.0000013					
			+1.8505633					
			″					″
		dM	70.886			—dZ		+33.29
						2d Term		.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Cerros to Whale	311	26	09.57
L	Whale to Lagoon Head	48	53	34
Z	Cerros to Lagoon Head	262	32	35.57
dZ		+	31	39.85
180		180	00	00
Z′	Lagoon Head to Cerros	83	04	15.42

	°	′	″			°	′	″
L	28	08	03.748	Cerros	M	115	13	22.960
dL	+	7	29.619	110,534.2 meters	dM	— 1	07	00.930
L′	28	15	33.367	Lagoon Head	M′	114	06	22.030

K	5.0434966	K^2	0.08699			h	—2.6684
cos Z	—9.1132024	$\sin^2 Z$	9.99262	(δL^2)	5.3058	$K^2 \sin^2 Z$	0.0796
B	8.5116951	C	1.13374	D	2.3120	E	5.8808
h	—2.6683941		1.21335		7.6178		—8.6188
	″						
1st Term	—466.009	3d Term.	+.004			dM^2	—0.813
2d Term	+ 16.344	—4th Term	+.042			F	7.856
	—449.665		+.046				8.668
3d and 4th Terms	+ .046						
—dL	—449.619						
	° ′ ″			Arg.		dM	—3.604327
λ	28 11 48.557	K	5.0434966	K	—217	sin λ	9.674404
		sin Z	9.9963116*n*	dM	+275	$\cos \frac{1}{2}$ dL ar. co.	0.000000
		A′	8.5093968	Corr.	+ 58		3.278731
		cos L′ ar. co.	0.0551157				
			—3.6043207				
			+0.0000058				
			—3.6043265				
			″				″
		dM	—4020.930			—dZ	—1899.90
						2d Term	—0000.05
							—1899.85

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Cerros to Lagoon Head	262	32	35.57
L	Lagoon Head to Top	22	46	57
Z	Cerros to Top	285	19	32.57
dZ		+ 1	01	22.22
180		180	00	00
Z′	Top to Cerros	106	20	54.79

	°	′	″			°	′	″
L	28	08	03.748	Cerros	M	115	13	22.960
dL	—	33	06.835	224,067.8 meters	dM	— 2	11	18.996
L′	27	34	56.913	Top	M′	113	02	03.964

K	5.3503795	K^2	0.70076			h	+3.2841
cos Z	+9.4221068	$\sin^2 Z$	9.96855	(dL^2)	6.5964	$K^2 \sin^2 Z$	0.6693
B	8.5116951	C	1.13374	D	2.3120	E	5.8808
h	+3.2841814		1.80305		8.9084		+9.8342
	″						
1st Term	+1923.895	3d Term	+.081			dM^3	—1.689
2d Term	+ 63.542	—4th Term	—.683			F	7.856
	+1987.437		—.602				—9.545
3d and 4th Terms	— .602						
—dL	+1986.835						
	° ′ ″			Arg.		dM	—3.896477
λ	27 51 30.330	K	5.3503795	K		sin λ	9.669586
		sin Z	—9.9842747	dM		$\cos \frac{1}{2}$ dL ar. co.	0.000005
		A′	8.5094112	Corr.	+80		—3.566068
		cos L′ ar. co.	0.0523975				
			3.8964629				
			+ 80				
			3.8964709				
			″				″
		dM	—7878.996			—dZ	—3681.87
						2d Term	— .35
							3682.22

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Cerros to Top	285	19	32.57
L	Top to Peak	24	49	42
Z	Cerros to Peak	310	09	14.57
dZ		+	26	29.13
180		180	00	00
Z′	Peak to Cerros	130	35	43.70

	°	′	″			°	′	″
L	28	08	03.748	Cerros	M	115	13	22.960
dL	—	42	59.117	122,549.4 meters	dM	—	56	49.876
L′	27	25	04.631	Peak	M′	114	16	33.084

K	5.0883113	K^2	0.17662			h		3.4095
cos Z	+9.8094558	$\sin^2 Z$	9.76654	(dL^2)	6.8230	$K^2 \sin^2 Z$		9.9432
B	8.5116951	C	1.13374	D	2.3120	E		5.8808
h	+3.4094622		1.07690		+9.1350			+9.2335
	″							
1st Term	+2567.215	3d Term	+.136			dM^2		—0.598
2d Term	+ 11.937	—4th Term	—.171			F		7.856
	+2579.152		.35					—8.454
3d and 4th Terms	— .035							
—dL	+2579.117							
	° ′ ″			Arg.		dM		—3.532739
λ	27 46 34.189	K	5.0883113	K	—267	sin λ		+9.668403
		sin Z	—9.8832715	dM	+198	$\cos \frac{1}{2}$dL ar. co.		0.000008
		A′	8.5094147	Corr.	— 69			3.201150
		cos L′ ar. co.	0.0517479					
			3.5327454					
			— 69					
			—3.5327385					
			″					″
		dM	—3409.876			—dZ		—1589.10
						2d Term		— .03
								—1589.13

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Cerros to Peak	310	09	14.57
L	Peak to Noble	11	57	19.50
Z	Cerros to Noble	322	06	34.07
dZ		+	14	36.36
180		180	00	00
Z′	Noble to Cerros	142	21	10.43

	°	′	″			°	′	″
L	28	08	03.748	Cerros	M	115	13	22.960
dL	—	35	47.352	83,620.20 meters	dM	—	31	11.610
L′	27	32	16.396	Noble	M′	114	42	11.350

K	4.9223112	K^2	9.84462			h		+3.3312
cos Z	+9.8971791	$\sin^2 Z$	9.57656	(dL^2)	4.6638	$K^2 \sin^2 Z$		9.4212
B	8.5116951	C	1.13374	D	2.3120	E		5.8808
h	+3.3311854		0.55492		6.9758			+8.6332
	″							
1st Term	+2143.805	3d Term	+.001			dM^2		—9.817
2d Term	+ 3.589	—4th Term	—.043			F		7.856
	+2147.394		—.042					—7.673
3d and 4th Terms	— .042							
—dL	+2147.352							
	° ′ ″			Arg.		dM		—3.272215
λ	27 55 10.072	K	4.9223112	K	—124	$\sin \lambda$		9.670462
		$\sin Z$	—9.7882778	dM	+ 59	$\cos \frac{1}{2}$dL ar. co.		0.000006
		A′	8.5094121	Corr.	— 65			—2.942683
		cos L′ ar. co.	0.0522207					
			3.2722218					
			— 65					
			3.2722153					
			″					″
		dM	—1871.610			—dZ		—876.36
						2d Term		—000.00

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Lagoon Head to Cerros	83	04	15.42
L	Cerros to Peak	72	51	28
Z	Lagoon Head to Peak	10	12	47.42
dZ		—	4	45.56
180		180	00	00
Z′	Peak to Lagoon Head	190	08	01.86

	°	′	″			°	′	″
L	28	15	33.275	Lagoon Head	M	114	06	22.338
dL	—	50	29.371	94,737.11 meters	dM	+	10	11.493
L′	27	25	03.904	Peak	M′	114	16	33.831

K		4.9765201	K^2	9.95304			h	+3.4813
cos Z		+9.9930638	$\sin^2 Z$	8.49745	(dL^2)	6.9626	$K^2 \sin^2 Z$	8.4505
B		8.5116871	C	1.13602	D	2.3133	E	5.8829
h		+3.4812710		+9.58651		+9.2759		+7.8147
		″						
1st Term		+3028.803	3d Term	+0.189			dM^3	
2d Term		+ .386	—4th Term	— .007			F	
		+3029.189		+ .182				
3d and 4th Terms		+ .182						
—dL		+3029.371						
	°	′	″		Arg.		dM	+2.786391
λ	27	50	18.589	K	4.9765201	K	—160	sin λ 9.669299
				sin Z	+9.2487249	dM	+ 6	$\cos \frac{1}{2}$ dL ar. co. 0.000011
				A′	8.5094147	Corr.	—154	+2.455701
				cos L′ ar. co.	0.0517471			
					2.7864068			
					154			
					+2.7863914			
					″			″
				dM	611.493		—dZ	285.56
							2d Term	0.00

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Lagoon Head to Peak	10	12	47.42
L	Peak to Top	65	02	24
Z	Lagoon Head to Top	305	10	23.42
dZ		+	30	10.94
180		180	00	00
Z′	Top to Lagoon Head	125	40	34.36

	°	′	″			°	′	″
L	28	15	33.275	Lagoon Head	M	114	06	22.338
dL	—	40	43.754	129,772.3 meters	dM	— 1	04	27.417
L′	27	34	49.521	Top	M′	113	01	54.921

K	5.1131819	K^2	0.22636			h		+3.3853
cos Z	+9.7604600	$\sin^2 Z$	9.82488	(dL^2)	6.7761	$K^2 \sin^2 Z$		0.0512
B	8.5116871	C	1.13602	D	2.3133	E		5.8829
h	+3.3853290		1.18726		+9.0894			+9.3194
	″							
1st Term	+2428.449	3d Term	+0.123			dM^3		—0.762
2d Term	+ 15.391	—4th Term	—0.209			F		7.856
	+2443.840		—0.086					—8.618
3d and 4th Terms	— .086							
—dL	+2443.754							
	° ′ ″			Arg.		dM		—3.587421
λ	27 55 11.398	K	5.1131819	K	—0.299	sin λ		9.670465
		sin Z	9.9124424	dM	+0.255	$\cos \frac{1}{2}$ dL ar.co.		—0.000008
		A′	8.5094112	Corr.	—0.044			—3.257894
		cos L′ ar. co.	0.05238900					
			3.5874254					
			—0.0000044					
			3.5874210					
			″					″
		dM	—3867.417			—dZ		—1810.90
						2d Term		— .04
								1810.94

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Noble to Whale	175 34 57.23
L	Whale to Summit	97 03 11
Z	Noble to Summit	272 38 08.23
dZ		+ 5 17.10
180		180 00 00
Z′	Summit to Noble	92 43 25.33

	° ′ ″			° ′ ″
L	27 32 16.436	Noble	M	114 42 11.478
dL	— 28.621	18,843.10 meters	dM	— 12 25.953
L′	27 31 47.815	Summit	M′	114 30 45.525

K	4.2751523	K^2	8.55030			h	1.4495
cos Z	+8.6626066	$\sin^2 Z$	9.99908	(dL^2)		$K^2 \sin^2 Z$	8.5493
B	8.5117330	C	1.12286	D		E	5.8709
h	1.4494919		+9.67224				6.0000
	″						
1st Term	28.151	3d Term	0.00000			dM^2	
2d Term	+ .470	—4th Term	0.00000			F	7.852
	+28.621						
3d and 4th Terms	0.000						
—dL	+28.621						
	° ′ ″			Arg.		dM	—2.836294
λ	27 32 02.125	K	4.2751523	K	—6	sin λ	9.664899
		sin Z	—9.9995403	dM	+9	cos ½ dL ar.co.	0.000000
		A′	8.5094123	Corr.	+3		2.501193
		cos L′ ar. co.	0.0521893				
			—2.8362945				
			″				″
		dM	—685.953			—dZ	—317.10
						2d Term	.00

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Noble to Cerros	142	21	10.43
L	Cerros to Peak	145	00	17
Z	Noble to Peak	287	21	27.43
dZ		+	11	49.66
180		180	00	00
Z′	Peak to Noble	107	33	17.09

	°	′	″			°	′	″
L	27	32	16.436	Noble	M	114	42	11.478
dL	—	7	11.352	44,259.50 meters	dM	—	25	37.902
L′	27	25	05.084	Peak	M′	114	16	33.576

K	4.6460066	K^2	9.29201			h	+2.6324
cos Z	9.4747039	$\sin^2 Z$	9.95952	(δL^2)	5.2697	$K^2 \sin^2 Z$	9.2515
B	8.5117330	C	1.12286	D	2.3059	E	5.8709
h	+2.6324435		+0.37439		7.5756		+7.7548
	″						
1st Term	+428.986	3d Term	+0.004			dM^3	9.561
2d Term	+ 2.368	—4th Term	—0.006			F	7.852
	+431.354		—0.002				7.413
3d and 4th Terms—	.002						
—dL	+431.352						
	° ′ ″			Arg.		dM	—3.186928
λ	27 28 40.760	K	4.6460066	K	—36	sin λ	9.664114
		sin Z	9.9797583	dM	+41	$\cos \frac{1}{2}$ dL ar.co.	0.000000
		A′	8.5094147	Corr.	+ 5		2.851042
		cos L′ ar. co.	0.0517485				
			3.1869281				
			+ 5				
			—3.1869286				
			″				″
		dM	—1537.902			—dZ	—709.66
						2d Term	.00

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Noble to Peak	287 21 27.43
L	Peak to Harris	34 12 17
Z	Noble to Harris	321 33 44.43
dZ		+ 6 54
180		180 00 00
Z′	Harris to Noble	141 40 38.43

	° ′ ″			° ′ ″
L	27 32 16.436	Noble	M	114 42 11.478
dL	— 16 53.948	39,811.41 meters	dM	— 14 59.691
L′	27 15 22.488	Harris	M′	114 27 11.787

K	4.6000076	K^2	9.20001			h	3.0056
cos Z	+9.8939199	$\sin^2 Z$	9.58711	(δL^2)	6.0120	$K^2 \sin^2 Z$	8.7872
B	8.5117330	C	1.12286	D	2.3059	E	5.8709
h	+3.0056605		+9.90998		+8.3179		+7.6637
	″						
1st Term	+1013.119	3d Term	0.021				
2d Term	+ .813	—4th Term	—0.005			dM^2	
	1013.932		+0.016			F	
3d and 4th Terms	+ .016						
—dL	+1013.948						
	° ′ ″			Arg.		dM	—2.954093
λ	27 23 49.484	K	4.6000076	K	—28	sin λ	9.662904
		sin Z	—9.7935548	dM	+14	$\cos \frac{1}{2}$ dL ar.co.	0.000091
		A′ cos L′ ar. co.	8.5094181	Corr.	—14		2.616998
			0.0511143				
			2.9540948				
		dM	— 14				
			—2.9540934				
			″				″
			—899.691			—dZ	414.00
						2d Term	.00

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Peak to Noble	107	33	17.09
L	Noble to Harris	63	09	03
Z	Peak to Harris	44	24	14.09
dZ		—	4	53.01
180		180	00	00
Z′	Harris to Peak	224	19	21.08

	°	′	″			°	′	″
L	27	25	04.562	Peak	M	114	16	33.489
dL	—	9	42.679	25,085.58 meters	dM	+	10	38.065
L′	27	15	21.882	Harris	M′	114	27	11.554

K	4.3994242	K^2	8.79885			h	+2.7651
cos Z	+9.8539566	$\sin^2 Z$	9.68982	(δL^2)	5.5309	$K^2 \sin^2 Z$	8.4886
B	8.5117405	C	1.12065	D	2.3045	E	5.8689
h	+2.7651213		+9.60932		7.8345		+7.1226
	″						
1st Term	+582.266	3d Term	+007			dM^3	8.414
2d Term	+ .407	—4th Term	—001			F	7.852
	+582.673		+006				6.266
3d and 4th Terms	+ .006						
—dL	+582.679						
	° ′ ″			Arg.		dM	+2.804865
λ	27 20 13.222	K	4.3994242	K	—12	sin λ	9.662024
		sin Z	+9.8449094	dM	+ 7	$\cos \frac{1}{2}$ dL ar. co.	0.000000
		A′	8.5094181	Corr.	— 5		+2.466889
		cos L′ ar. co.	0.0511136				
			+2.8048648				
			″				″
		dM	+638.065			—dZ	+293.01
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Peak to Lagoon Head	190	08	01.86
L	Lagoon Head to Top	71	17	25
Z	Peak to Top	261	25	26.86
dZ		+	34	30.11
180		180	00	00
Z′	Top to Peak	81	59	56.97

	°	′	″			°	′	″
L	27	25	04.562	Peak	M	114	16	33.489
dL	+	9	44.441	124,356.1 meters	dM	− 1	14	43.225
L′	27	34	49.003	Top	M′	113	01	50.264

K	5.0946672	K²	0.18933			h	−2.7799
cos Z	−9.1735328	sin² Z	9.99023	(δL²)	5.5306	K² sin² Z	0.1795
B	8.5117405	C	1.12065	D	2.3045	E	5.8689
h	−2.7799405		+1.30021		+7.8351		8.8283
	″						
1st Term	−602.477	3d Term	+007			dM²	−0.955
2d Term	+ 19.962	−4th Term	+067			F	7.852
	−582.515		+074				8.807
3d and 4th Terms	+ .074						
−dL	−582.441						
	° ′ ″			Arg.		dM	−3.651590
λ	27 29 56.582	K	5.0946672	K	−275	sin λ	9.664392
		sin Z	−9.9951168	dM	+344	cos ½ dL ar. co.	0.000000
		A′	8.5094112	Corr.	+ 69		−3.315982
		cos L′ ar. co.	0.0523884				
			3.6515836				
			+ 69				
			−3.6515905				
			″				″
		dM	−4483.225			−dZ	−2070.05
						2d Term	− .06
							2070.11

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Peak to Harris	44	24	04.09
L	Harris to Asuncion	41	44	18
Z	Peak to Asuncion	2	39	46.09
dZ		—		26.90
180		180	00	00
Z′	Asuncion to Peak	182	39	19.19

	°	′	″			°	′	″
L	27	25	04.562	Peak	M	114	16	33.489
dL	—	18	50.033	34,819.32 meters	dM	+		58.725
L′	27	06	14.529	Asuncion	M′	114	17	32.214

K	4.5418203	K²	9.08364			h		+3.0531
cos Z	+9.9995308	sin² Z	7.33412	(δL²)	6.1062	K² sin² Z		6.4178
B	8.5117405	C	1.12065	D	2.3045	E		5.8689
h	+3.0530916		+7.53841		+8.4107			+5.3298
	″							
1st Term	+1130.034	3d Term	+.026			dM²		.....
2d Term	+ .003	—4th Term	.000			F		.....
	+1130.037							.....
3d and 4th Terms	+ .026							
—dL	+1130.033							
	° ′ ″			Arg.		dM		+1.768821
λ	27 15 39.545	K	4.5418203	K	—23	sin λ		9.660908
		sin Z	+8.6670600	dM	+ 0	cos ½ dL ar. co.		.000002
		A′	8.5094213	Corr.	—23			+1.429731
		cos L′ ar. co.	0.0505217					
			1.7688210					
			″					″
		dM	+58.725			—dZ		+26.90
						2d Term		.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Peak to Asuncion	2	39	46.09
L	Asuncion to Table	39	52	24
Z	Peak to Table	322	47	22.09
dZ		+	8	08.22
180		180	00	00
Z′	Table to Peak	142	55	30.31

	°	′	″			M	°	′	″
L	27	25	04.562	Mean of quadrilaterals Nos. 10 and 11.	Peak 48,594.04 meters	M	114	16	33.489
dL	—	20	58.530			dM	—	17	46.495
L′	27	04	06.032		Table	M′	113	58	46.994

K	4.6865830	K^2	9.37317			h		+3.0994
cos Z	+9.9011416	$\sin^2 Z$	9.56315	(δL^2)		$K^2 \sin^2 Z$		8.9361
B	8.5117405	C	1.12065	D		E		5.8689
h	+3.0994651		+0.05697					+7.9044
	″							
1st Term	+1257.376	3d Term	+.032			dM^2		−9.084
2d Term	+ 1.140	−4th Term	−.008			F		7.852
	+1258.516		+.024					−6.936
3d and 4th Terms	+ .024							
−dL	+1258.540							
	° ′ ″			Arg.		dM		−3.027959
λ	27 14 35.297	K	4.6865830	K	−42	sin λ		9.660645
		sin Z	−9.7815726	dM	+20	cos ½ dL ar. co.		.000002
		A′	8.5094221	Corr.	−22			−2.688606
		cos L′ ar. co.	0.0503834					
			−3.0279589					
			″					″
		dM	−1066.495			−dZ		−488.21
						2d Term		− .01
								−488.22

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Peak to Table	322	47	22.09
L	Table to Rugged	12	14	30
Z	Peak to Rugged	310	32	52.09
dZ		+	12	43.73
180		180	00	00
Z′	Rugged to Peak	130	45	35.82

	°	′	″			°	′	″
L	27	25	04.562	Peak	M	114	16	33.489
dL	—	21	20.806	60,509.35 meters	dM	—	27	48.546
L′	27	03	43.756	Rugged	M′	113	48	44.943

K	4.7818225	K²	9.56364			h	+3.1065
cos Z	+9.8129684	sin² Z	9.76147	(dL²)	6.2150	K² sin² Z	9.3251
B	8.5117405	C	1.12065	D	2.3045	E	5.8689
h	+3.1065314		+0.44576		+8.5195		+8.3005
	″						″
1st Term	+1278.002	3d Term	+.033			dM³	—9.667
2d Term	+ 2.791	—4th Term	—.020			F	7.852
	+1280.793		+.013				7.519
3d & 4th Terms	+ .013						
—dL	+1280.806						
	° ′ ″			Arg.		dM	—3.222338
λ	27 14 24.159	K	4.7818225	K	—65	sin λ	9.660599
		sin Z	—9.8307358	dM	+48	cos ½dL ar. co.	2
		A′	8.5094222	Corr.	—17		—2.882939
		cos L′ ar. co.	0.0503504				
			3.2223399				
			— 17				
			3.2223382				
			″				″
		dM	—1668.546			—dZ	—763.73
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Peak to Rugged	310	32	52.09
L	Rugged to Loaf	17	11	06
Z	Peak to Loaf	293	21	46.09
dZ		+	18	46.68
180		180	00	00
Z′	Loaf to Peak	113	40	32.77

	°	′	″			°	′	″
L	27	25	04.562	Peak	M	114	16	33.489
dL	—	15	55.749	73,714.60 meters	dM	—	40	57.722
L′	27	09	08.813	Loaf	M′	113	35	35.767

K	4.8675536	K^2	9.73510			h	+2.9776
cos Z	+9.5983002	$\sin^2 Z$	9.92570	$(\delta l.^s)$	5.9607	$K^2 \sin^2 Z$	9.6608
B	8.5117405	C	1.12065	D	2.3045	E	5.8689
h	+2.9775943		+0.78145		+8.2652		+8.5073
	″						″
1st Term	+949.717	3d Term	+.018			dM^2	—0.171
2d Term	+ 6.046	—4th Term	—.032			F	7.852
	+955.763		—.014				—8.023
3d and 4th Terms	— .014						
—dL	+955.749						
	° ′ ″			Arg.		dM	3.390533
λ	27 17 06.687	K	4.8675536	K	— 97	sin λ	9.661264
		sin Z	—9.9628484	dM	+103	$\cos \frac{1}{2}$ dL ar. co.	1
		A′	8.5094203	Corr.	+ 6		3.051798
		cos L′ ar. co.	0.0507099				
			3.3905328				
			″				″
		dM	—2457.722			—dZ	—1126.67
						2d Term	— 1
							—1126.68

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Peak to Rugged	310	32	52.09
L	Rugged to Ballenas	18	33	57
Z	Peak to Ballenas	291	58	55.09
dZ		+	17	49.12
180		180	00	00
Z′	Ballenas to Peak	112	16	44.21

	°	′	″				°	′	″
L	27	25	04.562	Mean of quadrilaterals Nos. 11 and 12.	Peak 69,193.68 meters	M	114	16	33.489
dL	—	14	06.903			dM	—	38	50.962
L′	27	10	57.659		Ballenas	M′	113	37	42.527

K	4.8400664	K²	9.68013			h		+2.9250
cos Z	+9.5732370	sin² Z	+9.93444	(dL²)	5.8556	K² sin² Z		9.6145
B	8.5117405	C	1.12065	D	2.3045	E		5.8689
h	+2.9250439		+0.73522		+8.1601			+8.4084
	″							″
1st Term	+841.480	3d Term	+.014			dM²		—0.102
2d Term	+ 5.435	—4th Term	—.026			F		7.852
	+846.915		—.012					—7.954
3d and 4th Terms	— .012							
—dL	+486.903							
	° ′ ″			Arg.		dM		—3.367535
λ	27 18 01.060	K	4.8400664	K	—86	sin λ		9.661486
		sin Z	—9.9672211	dM	+94	cos ½dL ar. co.		1
		A′	8.5094196	Corr.	+ 8			—3.029022
		cos L′ ar. co.	0.0508274					
			3.3675345					
			+ 8					
			—3.3675353					
			″					″
		dM	—2330.962			—dZ		—1069.11
						2d Term		— 1
								—1069.12

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Harris to Peak	224	19	11.08
L	Peak to Asuncion	92	12	52
Z	Harris to Asuncion	316	32	03.08
dZ		+	4	24.63
180		180	00	00
Z′	Asuncion to Harris	136	36	27.71

	°	′	″			°	′	″
L	27	15	22.191	Harris	M	114	27	11.634
dL	—	9	07.357	23,197.59 meters	dM	—	9	39.328
L′	27	06	14.834	Asuncion	M′	114	17	32.306

K	4.3654427	K²	8.73088			h	+2.7380
cos Z	+9.8608080	sin² Z	+9.67508	(δL²)	5.4765	K² sin² Z	8.4060
B	8.5117506	C	1.11766	D	2.3028	E	5.8662
h	+2.7380013		+9.52362		+7.7793		+7.0102
	″						
1st Term	+547.018	3d Term	+.006			dM^3	.....
2d Term	+ .334	—4th Term	—.001			F	.....
	+547.352		+.005				.....
3d and 4th Terms	+ .005						
—dL	+547.357						
	° ′ ″			Arg.		dM	—2.762924
λ	27 10 48.512	K	4.3654427	K	—10	sin λ	9.659716
		sin Z	—9.8375389	dM	+ 6	cos ½dL ar. co.	.....
		A′	8.5094213	Corr.	— 4		—2.422640
		cos L′ ar. co.	0.0505220				
			—2.7629249				
			— 4				
			—2.7629245				
			″				″
		dM	— 579.328			—dZ	—264.63
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Harris to Peak	224	19	11.08
L	Peak to Table	69	28	43
Z	Harris to Table	293	47	54.08
dZ		+	12	57.80
180		180	00	00
Z′	Table to Harris	114	00	51.88

	°	′	″			M	°	′	″
L	27	15	22.191	Harris		M	114	27	11.634
dL	—	11	15.579	51,310.05 meters		dM	—	28	23.790
L′	27	04	06.612	Table		M′	113	58	47.844

K	4.7102024	K²	9.42040			h		2.8278
cos Z	+9.6058640	sin² Z	+9.92281	(δL^2)	5.6594	K² sin² Z		9.3432
B	8.5117506	C	1.11766	D	2.3028	E		5.8662
h	+2.8278170		+0.46087		+7.8622			+8.0372
	″							
1st Term	+672.693	3d Term	+0.007			dM^2		—9.694
2d Term	+ 2.890	—4th Term	—0.011			F		7.850
	+675.583		—0.004					—7.544
3d and 4th Terms	— .004							
—dL	+675.579							
	″			Arg.		dM		—3.231416
λ	27 09 44.401	K	4.7102024	K	—47	sin λ		9.659453
		sin Z	—9.9614074	dM	+50	cos ½ dL ar. co.		0.000001
		A′	8.5094221					
		cos L′ ar. co.	0.0503840	Corr.	+03			—2.890870
			—3.2314159					
			+0.0000003					
			—3.2314162					
			″					″
		dM	—1703.790			—dZ		777.80
						2d Term		.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Asuncion to Peak	182 39 19.19
L	Peak to Ballenas	79 37 56
Z	Asuncion to Ballenas	262 17 15.19
dZ		+ 18 10.38
180		180 00 00
Z′	Ballenas to Asuncion	82 35 25.57

	° ′ ″			° ′ ″
L	27 06 14.682	Asuncion	M	114 17 32.260
dL	+ 4 43.833	66,392.02 meters	dM	— 39 50.117
L′	27 10 58.515	Ballenas	M′	113 37 42.143

K	4.8221159	K^2	9.64423			h	−2.4616
cos Z	−9.1277476	$\sin^2 Z$	+9.99211	(dL^2)	4.9062	$K^2 \sin^2 Z$	9.6363
B	8.5117602	C	1.11484	D	2.3011	E	5.8637
h	−2.4616237		+0.75118		+7.2073		−7.9616
	″						
1st Term	−289.483	3d Term	+0.002			dM^2	−0.135
2d Term	+ 5.639	−4th Term	+0.009			F	7.849
	−283.844		+0.011				−7.984
3d and 4th Terms	+ .011						
−dL	−283.833						
	° ′ ″			Arg.		dM	−3.378419
λ	27 08 36.589	K	4.8221159	K	−79	sin λ	9.659155
		sin Z	−9.9960535	dM	+98	$\cos \frac{1}{2}$ dL ar. co.	.....
		A′	8.5094196	Corr.	+19		−3.037574
		cos L′ ar. co.	0.0508283				
			3.3784173				
			+0.0000019				
			−3.3784192				
			″				″
		dM	−2390.117			−dZ	−1090.37
						2d Term	— .01
							−1090.38

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Asuncion to Peak	182	39	19.19
L	Peak to Table	94	32	00
Z	Asuncion to Table	277	11	19.19
dZ		+	8	32.22
180		180	00	00
Z′	Table to Asuncion	97	19	51.41

	°	′	″			°	′	″
L	27	06	14.682	Mean from quadrilaterals Nos. 10 and 11.	Asuncion 31,240.74 meters Table	114	17	32.260
dL	—	2	08.270			—	18	44.863
L′	27	04	06.412			113	58	47.397

K	4.4947213	K^2	8.98944			h	2.1039	
cos Z	+9.0973855	$\sin^2 Z$	9.99315	(δL^2)	.....	$K^2 \sin^2 Z$	8.9825	
B	8.5117602	C	1.11484	D	2.3011	E	5.8637	
h	+2.1038670		+0.09743				6.9501	
	″							
1st Term	+127.019	3d Term	0.00000			dM^2	.....	
2d Term	+ 1.251	—4th Term	0.00000			F	.....	
	+128.270		0.00000				.....	
3d and 4th Terms	0.000							
—dL	+128.270							
	° ′ ″			Arg.		dM	—3.051100	
λ	27 05 10.547	K	4.4947213	K	—18	$\sin \lambda$	9.658353	
		sin Z	—9.9965727	dM	+23	$\cos \frac{1}{2}$ dL ar. co.	.....	
		A′	8.5094220	Corr.	+ 5		—2.709453	
		cos L′ ar. co.	0.0503838					
			—3.0510998					
			+0.0000005					
			—3.0511003					
			″				″	
		dM	—1124.863			—dZ	—512.22	
						2d Term	.....	

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Table to Peak	142	55	30.31
L	Peak to Ballenas	106	59	50
Z	Table to Ballenas	249	55	20.31
dZ		+	9	36.64
180		180	00	00
Z′	Ballenas to Peak	70	04	56.95

	°	′	″			°	′	″
L	27	04	06.352	Table	M	113	58	47.412
dL	+	06	51.852	37,066.21 meters	dM	—	21	04.728
L′	27	10	58.204	Ballenas	M′	113	37	42.684

K	4.5689782	K²	9.13796			h	—2.6164
cos Z	—9.5356662	sin² Z	9.94554	(dL²)	5.2295	K² sin² Z	9.08 5
B	8.5117625	C	1.11417	D	2.3007	E	5.8631
h	—2.6164069		+0.19767		7.5302		—7.5630
	″						
1st Term	—413.435	3d Term	+0.003			dM²	9.306
2d Term	+ 1.576	—4th Term	+0.004			F	7.849
	—411.859		0.007				7.155
3d and 4th Terms	+ .007						
—dL	—411.852						
	° ′ ″			Arg.		dM	—3.101997
λ	27 07 32.278	K	4.5689782	K	—25	sin λ	9.658911
		sin Z	—9.9727710	dM	+27	cos ½ dL ar.co.	0.000000
		A′	8.5094196	Corr.	+ 2		—2.760908
		cos L′ ar. co.	0.0508280				
			—3.1019968				
			+0.0000002				
			—3.1019970				
			″				″
		dM	—1264.728			—dZ	576.64
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Table to Peak	142	55	30.31
L	Peak to Loaf	113	21	01
Z	Table to Loaf	256	16	31.31
dZ		+	10	34.08
180		180	00	00
Z′	Loaf to Table	76	27	05.39

L	27	04	06.352	Table				M	113	58	47.412
dL	+	5	02.098	39,437.67 meters				dM	−	23	11.428
L′	27	09	08.450	Loaf				M′	113	35	35.984

K	4.5959113	K^2	9.19182			h		−2.4829
cos Z	−9.3752170	$\sin^2 Z$	9.97484	$(\delta l.^2)$	4.9603	$K^2 \sin^2 Z$		9.1667
B	8.5117625	C	1.11417	D	2.3007	E		5.8631
h	−2.4828908		+0.28083		+7.2610			−7.5127
	″							
1st Term	−304.012	3d Term	+ .002			dM^3		−9.431
2d Term	+ 1.909	−4th Term	+ .003			F		7.849
	−302.103		+ .005					−7.280
3d and 4th Terms	+ .005							
−dL	−302.098							
	° ′ ″			Arg.		dM		−3.143461
λ	27 06 37.401	K	4.5959113	K	−27	sin λ		9.658685
		sin Z	−9.9874192	dM	+33	$\cos \frac{1}{2}$dL ar. co.		0.000000
		A′	8.5094203	Corr.	+ 6			−2.802146
		cos L′ ar. co.	0.0507094					
			−3.1434608					
			″					″
		dM	−1391.428			−dZ		−634.08
						2d Term		.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Table to Peak	142 55 30.31
L	Peak to Rugged	129 22 25
Z	Table to Rugged	272 17 55.31
dZ		+ 4 34.15
180		180 00 00
Z′	Rugged to Table	92 22 29.46

	° ′ ″			° ′ ″
L	27 04 06.352	Table	M	113 58 47.412
dL	— 22.013	16,616.41 meters	dM	— 10 02.518
L′	27 03 44.339	Rugged	M′	113 48 44.894

K	4.2205372	K^2	8.44117			h	.....
cos Z	+8.6032427	$\sin^2 Z$	9.99931	(δL^2)	.....	$K^2 \sin^2 Z$	.....
B	8.5117625	C	1.11417	D	2.3007	E	.....
h	+1.3355424		+9.55465		+0.0000		.....
	″						
1st Term	+21.654	3d Term	.....			dM^2	.....
2d Term	+ .359	−4th Term	.....			F	7.849
	22.013		.....				.....
3d and 4th Terms	00.000						
−dL	+22.013						
	° ′ ″			Arg.		dM	−2.779970
λ	27 03 55.345	K	4.2205372	K	−5	sin λ	9.658018
		sin Z	−9.9996504	dM	+6	$\cos \frac{1}{2}$ dL ar. co.	0.000000
		A′	8.5094222	Corr.	+1		−2.437988
		cos L′ ar. co.	0.0503600				
			−2.7799699				
			″				″
		dM	−602.518			−dZ	−274.15
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Table to Ballenas	249 55 20.31
L	Ballenas to Notch	44 18 36
Z	Table to Notch	294 13 56.31
dZ		+ 7 03.16
180		180 00 00
Z′	Notch to Table	114 20 59.47

L	27	04	06.352	Table				M	113	58	47.412
dL	—	6	16.592	28,175.34 meters				dM	—	15	31.569
L′	26	57	49.760	Notch				M′	113	43	15.843

K	4.4498692	K^2	8.89974			h		+2.5749
cos Z	+9.6132469	$\sin^2 Z$	9.91988	(δL^2)	5.1517	$K^2 \sin^2 Z$		8.8196
B	8.5117625	C	1.11417	D	2.3007	E		5.8631
h	+2.5748786		+9.93379		+7.4524			+7.2576
	″							
1st Term	+375.732	3d Term	+ .003			dM^2		.....
2d Term	+ .859	−4th Term	− .002			F		.....
	+376.591		+ .001					.....
3d and 4th Terms	+ .001							
−dL	+376.592							
	° ′ ″			Arg.		dM		−2.969215
λ	27 00 58.056	K	4.4498692	K	−14	$\sin \lambda$		9.657286
		$\sin Z$	−9.9599419	dM	+15	$\cos \frac{1}{2}$ dL ar. co.		0.000000
		A′	8.5094242	Corr.	+ 1			−2.626501
		cos L′ ar. co.	0.0499797					
			−2.9692151					
			″					″
		dM	−931.569			−dZ		−423.16
						2d Term		.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

Z	Table to Rugged									° 272	′ 17	″ 55.31
L	Rugged to Pod									39	17	12
Z	Table to Pod									311	35	07.31
dZ										+	2	56.54
180										180	00	00
Z′	Pod to Table									131	38	03.85
L	° 27	′ 04	″ 06.352	Table					M	° 113	′ 58	″ 47.412
dL	−	5	09.065	14,323.74 meters					dM	−	6	28.521
L′	26	58	57.287	Pod					M′	113	52	18.891

K	4.1560564	K^2	8.31211			h		2.4898
cos Z	+9.8219949	$\sin^2 Z$	9.74777	(δL^2)	5.9800	$K^2 \sin^2 Z$		8.0599
B	8.5117625	C	1.11417	D	2.3007	E		5.8631
h	+2.4898138		+9.17405		8.2807			6.4128
	″							
1st Term	+308.897	3d Term	+ .019			dM^3		.....
2d Term	+ .149	−4th Term	.....			F		.....
	+309.046		.....					.....
3d and 4th Terms	+ .019							
−dL	+309.065							
	° ′ ″			Arg.		dM		−2.589415
λ	27 01 31.819	K	4.1560564	K	−4	sin λ		9.657426
		sin Z	−9.8738828	dM	+3	$\cos \frac{1}{2}$ dL ar. co.		0.000000
		A′	8.5094238	Corr.	−1			−2.246841
		cos L′ ar. co.	0.0500519					
			2.5894148					
			″					″
		dM	−388.521			−dZ		−176.54
						2d Term		.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Table to Pod	311	35	07.31
L	Pod to Hip	59	30	39
Z	Table to Hip	11	05	46.31
dZ		—		32.86
180		180	00	00
Z′	Hip to Table	191	05	13.45

		°	′	″			°	′	″
L		27	04	06.352	Table	M	113	58	47.412
dL		—	5	30.423	10,363.31 meters	dM	+	1	12.326
L′		26	58	35.929	Hip	M′	113	59	59.738

K	4.0155084	K²	8.03102			h		2.5191
cos Z	+9.9918042	sin² Z	8.56867	(δL²)	5.0382	K² sin² Z		6.5997
B	8.5117625	C	1.11417	D	2.3007	E		5.8631
h	+2.5190751		+7.71386		7.3389			.....
	″							
1st Term	+330.426	3d Term	+.002					
2d Term	+ .005	—4th Term	.000			dM²		.....
	+330.421					F		.....
3d and 4th Terms	+ .002							.....
—dL	+330.423							
	° ′ ″			Arg.		dM		+1.859294
λ	27 01 21.140	K	4.0155084	K	—2	sin		9.657382
		sin Z	9.2843333	dM	+0	cos ½ dL ar. co.		0.000000
		A′	8.5094239	Corr.	—2			+1.516676
		cos L′ ar. co.	0.0500289					
			1.8592943					
			″					″
		dM	+72.326			—dZ		+32.86
						2d Term		.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Ballenas to Table	70	04	56.95
L	Table to Rugged	16	17	37
Z	Ballenas to Rugged	53	47	19.95
dZ		—	5	01.54
180		180	00	00
Z′	Rugged to Ballenas	233	42	18.41

	°	′	″			°	′	″
L	27	10	58.126	Ballenas	M	113	37	42.451
dL	—	7	14.028	22,589.86 meters	dM	+	11	01.433
L′	27	03	44.098	Rugged	M′	113	48	43.884

K	4.3539135	K^2	8.70783			h		+2.6371
cos Z	+9.7714128	$\sin^2 Z$	9.81358	(δL^2)	5.2755	$K^2 \sin^2 Z$		8.7014
B	8.5117553	C	1.11630	D	2.3020	E		5.8650
h	+2.6370816		9.63771		+7.5775			+7.2035
	″							″
1st Term	+433.592	3d Term	+.004			dM^2		7.731
2d Term	+ .434	—4th Term	—.002			F		7.850
	+434.026		+.002					
3d and 4th Terms	+ .002							
—dL	+434.028							
	° ′ ″			Arg.		dM		+2.820486
γ	27 07 21.112	K	4.3539135	K	—10	sin λ		9.658865
		sin Z	+9.9067904	dM	+12	$\cos \frac{1}{2}$dL ar. co.		0.000000
		A′	8.5094222	Corr.	+ 2			+2.479351
		cos L′ ar. co.	0.0503597					
			+2.8204860					
			″					″
		dM	+661.433			—dZ		+301.54
						2d Term		

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Ballenas to Table	70 04 56.95
L	Table to Hip	11 47 52
Z	Ballenas to Hip	58 17 04.95
dZ		— 10 08.58
180		180 00 00
Z′	Hip to Ballenas	238 06 56.37

	° ′ ″			° ′ ″
L	27 10 58.126	Ballenas	M	113 37 42.451
dL	— 12 21.998	43,337.86 meters	dM	+ 22 16.850
L′	26 58 36.128	Hip	M′	113 59 59.301

K	4.6368675	K^2	9.27373			h	+2.8694
cos Z	+9.7207370	$\sin^2 Z$	9.85953	(δL^2)	5.7408	$K^2 \sin^2 Z$	9.1333
B	8.5117553	C	1.11630	D	2.3020	E	5.8650
h	+2.8693598		+0.24956		+8.0428		+7.8677
	″						
1st Term	+740.218	3d Term	+.011			dM^3	.....
2d Term	+ 1.776	—4th Term	—.007			F	.....
	+741.994		+.004				.....
3d and 4th Terms	+ .004						
—dL	+741.998						
	° ′ ″			Arg.		dM	+3.126083
λ	27 04 47.127	K	4.6368675	K	—33	sin λ	9.658231
		sin Z	+9.9297625	dM	+30	$\cos \frac{1}{2}$ dL ar. co.	.000001
		A′	8.5094239	Corr.	—03		+2.784315
		cos L′ ar. co.	0.0500290				
			+3.1260826				
			″				″
		dM	+1,336.850			—dZ	+608.58
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Ballenas to Table	70 04 56.95
L	Table to Notch	49 20 47
Z	Ballenas to Notch	20 44 09.95
dZ		— 2 31.55
180		180 00 00
Z′	Notch to Ballenas	200 41 38.40

	° ′ ″			° ′ ″
L	27 10 58.126	Ballenas	M	113 37 42.451
dL	— 13 08.270	25,938.11 meters	dM	+ 5 32.984
L′	26 57 49.856	Notch	M′	113 43 15.435

K	4.4139384	K^2	8.82788			h	2.8966
cos Z	+9.9709143	$\sin^2 Z$	9.09816	(δL^2)	5.7933	$K^2 \sin^2 Z$	7.9260
B	8.5117553	C	1.11630	D	2.3020	E	5.8650
h	+2.8966080		+9.04234		8.0953		+6.6876
	″						″
1st Term	+788.148	3d Term	+.012			dM^2	7.567
2d Term	+ .110	—4th Term	.000			F	7.850
	+788.258						.....
3d and 4th Terms	+ .012						
—dL	+788.270						
	° ′ ″			Arg.		dM	+2.522423
λ	27 04 23.991	K	4.4139384	K	—12	$\sin \lambda$	9.658136
		$\sin Z$	+9.5490819	dM	+ 2	$\cos \frac{1}{2} dL$ ar. co.	1
		A′	8.5094242	Corr.	—10		2.180560
		cos L′ ar. co.	0.0499796				
			+2.5224241				
			— 10				
			+2.5224231				
			″				n
		dM	+332.984			—dZ	+151.55
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Ballenas to Notch	20 44 09.95
L	Notch to Abre	8 18 36
Z	Ballenas to Abre	12 25 33.95
dZ		— 2 30.38
180		180 00 00
Z′	Abre to Ballenas	192 23 03.57

	° ′ ″			° ′ ″
L	27 10 58.126	Ballenas	M	113 37 42.451
dL	— 22 29.346	42,522.25 meters	dM	+ 5 31.302
L′	26 48 28.780	Abre	M′	113 43 13.753

E	4.6286162	K^2	9.25723			h	.....
cos Z	+9.9897054	$\sin^2 Z$	8.66560	(δL^2)	6.2602	$K^2 \sin^2 Z$	.....
B	8.5117553	C	1.11630	D	2.3020	E	.....
h	+3.1300769		+9.03913		+8.5622		.....
	″						
1st Term	+1349.202	3d Term	+.036			dM^2	.....
2d Term	+ .109	—4th Term	—.001			F	.....
	+1349.311		+.035				.....
3d & 4th Terms	+ .035						
—dL	+1349.346						
	° ′ ″			Arg.		dM	2.520224
λ	26 59 43.453	K	4.6286162	K	—33	sin λ	9.656978
		sin Z	+9.3328023	dM	+ 2	$\cos \frac{1}{2}$ dL ar. co.	2
		A′	8.5094275	Corr.	—31		2.177204
		cos L′ ar. co.	0.0493806				
			2.5202266				
			— 31				
			2.5202235				
			″				″
		dM	+331.302			—dZ	150.38
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Ballenas to Notch	20	44	09.95
L	Notch to South Base	26	28	38
Z	Ballenas to South Base	354	15	31.95
dZ		+	1	25.83
180		180	00	00
Z′	South Base to Ballenas	174	16	57.78

	°	′	″			°	′	″
L	27	10	58.126	Ballenas	M	113	37	42.451
dL	—	28	11.958	52,335.25 meters	dM	—	3	09.401
L′	26	42	46.168	South Base	M′	113	34	33.050

K	4.7187943	K^2	9.43759			h		+3.2284
cos Z	+9.9978161	$\sin^2 Z$	8.00029	(δL^2)	6.4567	$K^2 \sin^2 Z$		7.4379
B	8.5117553	C	1.11630	D	2.3020	E		5.8650
h	+3.2283657		+8.55418		+8.7587			.....
	″							
1st Term	+1691.865	3d Term	+.057			dM^3		.....
2d Term	+ .036	—4th Term	.....			F		.....
	+1691.901		.....					.....
3d & 4th Terms	+ .057							
—dL	+1691,958							
	° ′ ″			Arg.		dM		—2.277383
λ	26 56 52.147	K^2	4.7187943	K	—48	$\sin \lambda$		9.656270
		$\sin Z$	—9.0001473	dM	0	$\cos \frac{1}{2}$dL ar. co.		.000004
		A′	8.5094294	Corr.	.....			—1.933657
		$\cos L'$ ar. co.	0.0490164					
			2.2773874					
			— 48					
			—2.2773826					
			″					″
		dM	—189.401			—dZ		—85.83
						2d Term		.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Rugged to Peak	130	45	35.82
L	Peak to Loaf	114	30	46
Z	Rugged to Loaf	245	16	21.82
dZ		+	5	59.99
180		180	00	00
Z′	Loaf to Rugged	65	22	21.81

	°	′	″			°	′	″
L	27	03	44.064	Rugged	M	113	48	44.574
dL	+	5	24.503	23,921.80 meters	dM	—	13	09.146
L′	27	09	08.567	Loaf	M′	113	35	35.428

K	4.3787940	K^2	8.75758			h	−2.5120
cos Z	−9.6214873	$\sin^2 Z$	9.91647	(δL^2)	5.0224	$K^2 \sin^2 Z$	8.6740
B	8.5117629	C	1.11406	D	2.3006	E	5.8630
h	−2.5120442		+9.78811		+7.3230		−7.0490
	″						
1st Term	−325.120	3d Term	+.002			dM^3	8.093
2d Term	+ .614	−4th Term	+.001			F	7.849
	−324.506		+.003				.....
3d and 4th Terms	+ .003						
−dL	−324.503						
				Arg.		dM	−2.897659
λ	27 06 26.315	K	4.3787940	K	−11	sin λ	9.658639
		sin Z	−9.9582337	dM	+11	$\cos \frac{1}{2}$ dL ar. co.	.....
		A′	8.5094203	Corr.	.....		−2.556298
		cos L′ ar. co.	0.0507095				
			2.8871575				
			″				″
		dM	−789.146			−dZ	−359.99
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Rugged to Table	92	22	29.46
L	Table to Hip	29	21	48
Z	Rugged to Hip	63	00	41.46
dZ		—	5	06.57
180		180	00	00
Z′	Hip to Rugged	242	55	34.89

	°	′	″			°	′	″
L	27	03	44.064	Rugged	M	113	48	44.574
dL	—	5	08.379	20,883.84 meters	dM	+	11	14.821
L′	26	58	35.685	Hip	M′	113	59	59.395

K	4.3198104	K^2	8.63962			h		+2.4884
cos Z	+9.6568754	$\sin^2 Z$	9.89985	(δL^2)	4.9782	$K^2 \sin^2 Z$		8.5395
B	8.5117629	C	1.11406	D	2.3006	E		5.8630
h	+2.4884487		9.65353		7.2788			+6.8909
	″							″
1st Term	+307.928	3d Term	+.002			dM^2		8.487
2d Term	+ .450	—4th Term	—.001			F		7.849
	+308.378		+.001					.....
3d and 4th Terms	+ .001							
—dL	+308.379							
	° ′ ″			Arg.		dM		+2.829188
λ	27 01 09.874	K	4.3198104	K	—9	sin λ		9.657335
		sin Z	+9.9499254	dM	+9	$\cos\frac{1}{2}$ dL ar. co.		.....
		A′	8.5094239	Corr.	0			+2.486523
		cos L′ ar. co.	0.0500288					
			2.8291885					
			″					″
		dM	+674.821			—dZ		+306.57
						2d Term		.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Rugged to Table	92 22 29.46
L	Table to Pod	58 37 43
Z	Rugged to Pod	33 44 46.46
dZ		— 1 37.21
180		180 00 00
Z′	Pod to Rugged	213 43 09.25

	° ′ ″			° ′ ″
L	27 03 44.064	Rugged	M	113 48 44.574
dL	— 4 46.985	10,620.87 meters	dM	+ 3 33.960
L′	26 58 57.079	Pod	M′	113 52 18.534

K	4.0261601	K^2	8.05232			h	2.4578
cos Z	+9.9198654	$\sin^2 Z$	9.48939	(dL^2)	4.9156	$K^2 \sin^2 Z$	7.5417
B	8.5117629	C	1.11406	D	2.3006	E	5.8630
h	+2.4577884		+8.65577		7.2162		5.8625
	″						
1st Term	+286.938	3d Term	+ .002			dM^2	.....
2d Term	+ .045	—4th Term	.....			F	7.849
	286.983		.....				.....
3d and 4th Terms	+ .002						
—dL	+286.985						
	° ′ ″			Arg.		dM	+2.330332
λ	27 01 20.571	K	4.0261601	K	—2	sin λ	9.657379
		sin Z	+9.7446963	dM	0	$\cos \frac{1}{2} dL$ ar. co.	0.000000
		A′	8.5084238	Corr.	—2		+1.987711
		cos L′ ar. co.	0.0500517				
			2.3303317				
			″				″
		dM	+213.960			—dZ	+97.21
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Hip to Ballenas	238	06	56.37
L	Ballenas to Notch	34	45	25
Z	Hip to Notch	272	52	21.37
dZ		+	7	35.29
180		180	00	00
Z′	Notch to Hip	92	59	56.66

	°	′	″			°	′	″
L	26	58	35.914	Hip	M	113	59	59.478
dL	–		46.133	27,722.34 meters	dM	–	16	43.894
L′	26	57	49.781	Notch	M′	113	43	15.584

K		4.4428299	K^2	8.88565			h	+1.6546
cos Z		+8.6999666	$\sin^2 Z$	9.99891	(dL^2)	.....	$K^2 \sin^2 Z$	8.8846
B		8.5117681	C	1.11246	D	2.2097	E	5.8616
h		+1.6545646		+9.99702		.....		+6.4008
		″						
1st Term		+45.140	3d Term	.....			dM^2	–9.005
2d Term		+ .993	–4th Term	.....			F	7.849
		+46.133		.....				.....
3d and 4th Terms		.....						
–dL		+46.133						
	°	′	″		Arg.		dM	–3.001688
λ	26	58	12.847	K	K	–14	sin λ	9.656604
				sin Z	dM	+17	$\cos \frac{1}{2}$ dL ar. co.	0.000000
				A′	Corr.	+ 3		–2.658292
				cos L′ ar. co.	0.0499797			
					3.0016880			
					″			″
				dM	–1003.894		–dZ	–455.29
							2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Hip to Rugged	242	55	34.89
L	Rugged to Pod	24	04	38
Z	Hip to Pod	267	00	02.89
dZ		+	6	50.71
180		180	00	00
Z′	Pod to Hip	87	06	53.60

	°	′	″			°	′	″
L	26	58	35.914	Hip	M	113	59	59.478
dL	+		21.425	12,725.78 meters	dM	−	7	40.856
L′	26	58	57.339	Pod	M′	113	52	18.622

K	4.1046843	K^2	8.20937			h	.....
cos Z	−8.7186840	$\sin^2 Z$	9.99881	(δL^2)	.....	$K^2 \sin^2 Z$	.....
B	8.5117681	C	1.11246	D	.....	E	.....
h	−1.3351364		+9.32064		.....		.....
	″						
1st Term	−21.634	3d Term	.....			dM^3	.....
2d Term	+ .209	−4th Term	.....			F	7.849
	−21.425		.....				.....
3d and 4th Terms	.....						
−dL	−21.425						
	° ′ ″			Arg.		dM	−2.663565
λ	26 58 46.626	K	4.1046843	K	−3	sin λ	9.949974
		sin Z	−9.9994047	dM	+4	$\cos \frac{1}{2}$ dL ar. co.	0.000000
		A′	8.5094238	Corr.	+1		−2.613539
		cos L′ ar. co.	0.0500519				
			−2.6635648				
			″				″
		dM	−460.856			−dZ	−410.71
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		° ′ ″
Z	Notch to Ballenas	200 41 38.40
L	Ballenas to Abre	159 09 56
Z	Notch to Abre	359 51 34.40
dZ		+ 00.69
180		180 00 00
Z′	Abre to Notch	179 51 35.09

	° ′ ″			° ′ ″
L	26 57 49.799	Notch	M	113 43 15.621
dL	— 9 20.987	17,205.55 meters	dM	— 1.531
L′	26 48 28.812	Abre	M′	113 43 14.090

K	4.2371804	K^2	8.47436			h	.....
cos Z	+9.9999987	$\sin^2 Z$	4.77780	(δL^2)	5.4979	$K^2 \sin^2 Z$	.....
B	8.5117690	C	1.11222	D	2.2996	E	.....
h	+2.7489481		4.36438		7.7975		.....
	″						
1st Term	+560.981	3d Term	+ .006			dM^3	.....
2d Term	.....	—4th Term	.....			F	.....
	+560.981		+ .006				
3d and 4th Terms	+ .006						
—dL	+560.987						
	° ′ ″			Arg.		dM	—0.184889
λ	26 53 09.305	K	4.2371804	K	—5	$\sin \lambda$	9.655345
		$\sin Z$	7.3889013	dM	0	$\cos \frac{1}{2}$ dL ar. co.	.....
		A′	8.5094275	Corr.	—5		—9.840234
		cos L′ ar. co.	0.0493806				
			0.1848898				
			— 5				
			—0.1848893				
			″				″
		dM	—1.531			—dZ	—0.69
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Notch to Ballenas	200	41	38.40
L	Ballenas to South Base	131	51	43
Z	Notch to South Base	332	33	21.40
dZ		+	3	55.85
180		180	00	00
Z′	South Base to Notch	152	37	17.25

	°	′	″		M	°	′	″
L	26	57	49.799	Notch	M	113	43	15.621
dL	—	15	03.685	31,330.10 meters	dM	—	8	42.392
L′	26	42	46.114	South Base	M′	113	34	33.229

K	4.4959617	K^2	8.99192			h	+2.9559
cos Z	+9.9481494	$\sin^2 Z$	9.32718	(δL^2)	5.9120	$K^2 \sin^2 Z$	8.3191
B	8.5117690	C	1.11222	D	2.2996	E	5.8614
h	+2.9558801		+9.43132		8.2116		+7.1364
	″						
1st Term	+903.400	3d Term	+.016			dM^2	....
2d Term	+ .270	—4th Term	—.001			F	.....
	+903.670		+.015				.....
3d and 4th Terms	+ .015						
—dL	+903.685						
				Arg.		dM	—2.717996
λ	26 50 17.956	K	4.4959617	K	—18	sin λ	9.654633
		sin Z	—9.6635900	dM	+ 5	cos ½dL ar. co.	0.000001
		A′	8.5094294	Corr.	—13		—2.372630
		cos L′ ar. co.	0.0490164				
			2.7179975				
			0.0000013				
			—2.7179962				
			″				″
		dM	—522.392			—dZ	235.85
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Notch to South Base	332	33	21.40
L	South Base to Dish	59	49	09
Z	Notch to Dish	272	44	12.40
dZ		+	3	50.17
180		180	00	00
Z′	Dish to Notch	92	48	02.57

	°	′	″			°	′	″
L	26	57	49.799	Notch	M	113	43	15.621
dL	—		22.002	14,018.41 meters	dM	—	8	27.672
L′	26	57	27.797	Dish	M′	113	34	47.949

K		4.1466986	K²	8.29340			h	.....
cos Z		+8.6789517	sin² Z	9.99901	(dL^2)	.....	K² sin² Z	.....
B		8.5117690	C	1.11222	D	.....	E	.....
h		+1.3374193		+9.40463		.....		.....
		″						
1st Term		+21.748	3d Term	.....			dM^2	.....
2d Term		+ .254	—4th Term	.....			F	7.849
		22.002						
3d and 4th Terms		.....						
—dL		+22.202						
	°	′	″		Arg.		dM	—2.705583
λ	26	57	38.798	K	4.1466986	K —3	sin λ	9.656463
				sin Z	—9.9995044	dM +5	cos ½dL ar. co.	0.000000
				A′	8.5094243	Corr. +2		—2.362046
				cos L′ ar. co.	0.0499559			
					2.7055834			
					″			″
				dM	—507.672		—dZ	—230.17
							2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Abre to Ballenas	192	23	03.57
L	Ballenas to South Base	113	52	33
Z	Abre to South Base	306	15	36.57
dZ		+	3	54.46
180		180	00	00
Z′	South Base to Abre	126	19	31.03

	°	′	″			°	′	″
L	26	48	28.796	Abre	M	113	43	13.922
dL	—	5	43.298	17,849.85 meters	dM	—	8	40.712
L′	26	42	45.498	South Base	M′	113	34	33.210

K	4.2516345		8.50327			h		+2.5353
cos Z	+9.7719200	K^2	9.81304	(dL^2)	5.0713	$K^2 \sin^2 Z$		8.3163
B	8.5117786	$\sin^2 Z$	1.10930	D	2.2978	E		5.8588
h	+2.5353331	C	+9.42561		7.3691			+6.7104
	″							
1st Term	+343.031	3d Term	+.002			dM^2		.....
2d Term	+ .266	—4th Term	—.001			F		.....
	+343.297		+.001					.....
3d and 4th Terms	+ .001							
—dL	+343.298							
	° ′ ″			Arg.		dM		—2.716598
λ	26 45 37.147	K	4.2516345	K	—6	$\sin \lambda$		9.653463
		$\sin Z$	—9.9065181	dM	+5	$\cos \frac{1}{2}$ dL ar. co.		0.000000
		A′	8.5094294	Corr.	—1			—2.370061
		$\cos L'$ ar. co.	0.0490161					
			2.7165980					
			″					″
		dM	—520.712			—dZ		—234.46
			′ ″			2d Term		.....
			8 40.712					

Computation of the latitudes, longitudes, and azimuths, etc.—**Continued.**

		°	′	″
Z	Abre to South Base	306	15	36.57
L	South Base to North Base	13	10	43
Z	Abre to North Base	293	04	53.37
dZ		+	4	02.93
180		180	00	00
Z′	North Base to Abre	113	08	56.50

	°	′	″			°	′	″
L	26	48	28.796	Abre	M	113	43	13.922
dL	—	3	26.584	16,195.18 meters	dM	—	8	59.186
L′	26	45	02.212	North Base	M′	113	34	14.736

K	4.2093858	K^2	8.41877			h	.....
cos Z	+9.5933314	$\sin^2 Z$	9.92753	(δL^2)	4.6303	$K^2 \sin^2 Z$	.....
B	8.5117786	C	1.10930	D	2.2978	E	.....
h	+2.3144958		+9.45560		6.9281		.....
	″						
1st Term	+206.298	3d Term	.001			dM^3	.....
2d Term	+ .285	—4th Term	.000			F	.....
	+206.583						
3d and 4th Terms	+ .001						
—dL	+206.584						
	° ′ ″			Arg.		dM	—2.731739
λ	26 46 45.504	K	4.2093858	K	—5	sin λ	9.653748
		sin Z	—9.9637632	dM	+5	$\cos \frac{1}{2}$ dL ar. co.	0.000000
		A′	8.5094286	Corr.	0		—2.385487
		cos L′ ar. co.	0.0491611				
			—2.7317387				
			″				″
		dM	—539.186			—dZ	—242.93
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Abre to South Base	306	15	36.57
L	South Base to Sage	21	05	27
Z	Abre to Sage	285	10	09.57
dZ		+	3	29.50
180		180	00	00
Z′	Sage to Abre	105	13	39.07

	°	′	″			°	′	″
L	26	48	28.796	Abre	M	113	43	13.922
dL	—	1	53.320	13,303.18 meters	dM	—	7	44.774
L′	26	46	35.476	Sage	M′	113	35	29.148

K	4.1239555	K²	8.24791			h	2.0535
cos Z	+9.4177581	sin² Z	9.90920	(dL²)	4.1086	K² sin² Z	8.2171
B	8.5117786	C	1.10930	D	2.2978	E	5.8588
h	+2.0534922		9.32641		6.4064		6.1294
	″						
1st Term	+113.108	2d Term	.....			dM³	.....
2d Term	+ .212	−4th Term	.....			F	.....
	+113.320		.....				.....
3d and 4th Terms	.....						
−dL	+113.320						
	° ′ ″			Arg.		dM	−2.667242
λ	26 47 32.136	K	4.1239555	K	−3	sin λ	9.653942
		sin Z	−9.9845978	dM	+4	cos ½ dL ar. co.	0.000000
		A′	8.5094281	Corr.	+1		−2.321184
		cos L′ ar. co.	0.0492601				
			2.6672417				
			″				″
		dM	−464.774			−dZ	−209.50
						2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Abre to Notch	179	51	35.09
L	Notch to Dish	40	01	45
Z	Abre to Dish	219	53	20.09
dZ		+	3	48.85
180		180	00	00
Z′	Dish to Abre	39	57	08.94

	°	′	″			°	′	″
L	26	48	28.796	Abre	M	113	43	13.922
dL	+	9	02.410	21,766.91 meters	dM	−	8	26.107
L′	26	57	31.206	Dish	M′	113	34	47.815

K	4.3377969	K²	8.67559			h		−2.7345
cos Z	−9.8849591	sin² Z	9.61412	*(δL²)	5.4687	K² sin² Z		8.2897
B	8.5117786	C	1.10930	D	2.2978	E		5.8588
h	−2.7345346		+9.39901		7.7665			−6.8830
	″							
1st Term	−542.668	3d Term	.006			dM^2		.....
2d Term	+ .251	−4th Term	+.001			F		7.847
	−542.417		.007					.....
3d and 4th Terms	+ .007							
−dL	−542.410							
	° ′ ″			Arg.		dM		−2.704242
λ	26 53 00.001	K	4.3377969	K	−9	sin λ		9.655307
		sin Z	−9.8070620	dM	+4	cos ½ dL ar. co.		.....
		A′	8.5094243	Corr.	−5			−2.359549
		cos L′ ar. co.	0.0499596					
			−2.7042425					
			″					″
		dM	−506.107			−dZ		−228.85
						2d Term		.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	South Base to Abre	126	19	31.03
L	Abre to Sage	41	20	37
Z	South Base to Sage	167	40	08.03
dZ		—		25.21
180		180	00	00
Z′	Sage to South Base	347	39	42.82

	°	′	″			°	′	″
L	26	42	45.927	South Base	M	113	34	33.163
dL	+	3	49.998	7,245.75 meters	dM	+		56.014
L′	26	46	35.925	Sage	M′	113	35	29.177

K		3.8600831	K^2	7.72017			h	.....
cos Z		−9.9898634	$\sin^2 Z$	8.65904	(dL^2)	4.7235	$K^2 \sin^2 Z$	.....
B		8.5117844	C	1.10751	D	2.2968	E	.....
h		2.3617309		7.48672		7.0203		.....
		″						
1st Term		−230.002	3d Term	+.001			dM^2	.....
2d Term		+ .003	−4th Term	.....			F	.....
		−229.999		.....				.....
3d and 4th Terms		+ .001						
−dL		−229.998						
	°	′	″		Arg.		dM	+1.748293
λ	26	44	40.926	K	3.8600831	K	.....	sin λ	9.653228
				$\sin^2 Z$	+9.3295214	dM	.....	$\cos \frac{1}{2}$dL ar. co.	0.000000
				A′	8.5094281	Corr.	.....		+1.401521
				cos L′ ar. co.	0.0492606				
					1.7482932				
					″				″
				dM	+56.014			−dZ	25.21
								2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	South Base to Abre	126	19	31.03
L	Abre to Dish	52	57	31
Z	South Base to Dish	179	17	02.03
dZ		—		5.58
180		180	00	00
Z′	Dish to South Base	359	16	56.45

	°	′	″			°	′	″
L	26	42	45.927	South Base	M	113	34	33.163
dL	+	14	46.183	27,276.01 meters	dM	+		12.360
L′	26	57	32.110	Dish	M′	113	34	45.523

K		4.4357808	K^2	8.87156			h	−2.9475
cos Z		−9.9999661	$\sin^2 Z$	6 19368	(δL^2)	5.8950	$K^2 \sin^2 Z$	5.0653
B		8.5117844	C	1.10751	D	2.2968	E	5.8574
h		−2.9475313		6.17275		8.1918		.8702
		″						
1st Term		−886.199	3d Term	+.016			dM^3	.....
2d Term		.....	−4th Term	.....			F	.....
		−886.199		.....				.....
3d and 4th Terms		+ .016						
−dL		−886.183						
	°	′	″		Arg.		dM	+1.092001
λ	26	50	09.018	K	4.4357808	K	−13	$\sin \lambda$ 9.654596
				sin Z	+8.0968414	dM	.....	$\cos \frac{1}{2}$ dL ar. co. .000001
				A′	8.5094243	Corr.	−13	+0.746598
				cos L′ ar. co.	0.0499605			
					+1.0920070			
					— 13			
					+1.0920057			
					″			″
				dM	+12.360		−dZ	+5.58
							2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	South Base to Sage	167	40	08.03
L	Sage to North Base	19	15	17
Z	South Base to North Base	186	55	25.03
dZ		+		8.32
180		180	00	00
Z′	North Base to South Base	6	55	33.35

		°	′	″			°	′	″
L		26	42	45.927	South Base	M	113	34	33.163
dL		+	2	16.775	4,240.336 meters	dM	—		18.499
L′		26	45	02.702	North Base	M′	113	34	14.664

K	3.6274003	K^2	7.25480			h		
cos Z	—9.9968214	$\sin^2 Z$	8.16230	(δL^2)	4.2720	$K^2 \sin^2 Z$		
B	8.5117844	C	1.10751	D	2.2068	E		
h	—2.1360061		6.52461					
	″							
1st Term	—136.775	3d Term				dM^3		
2d Term	+ 0.00	—4th Term				F		
	136.775							
3d and 4th Terms								
—dL	136.775							
	° ′ ″			Arg.		dM	—1.267144	
λ	26 43 54.314	K	3.6274003	K		$\sin \lambda$	9.653033	
		$\sin Z$	—9.0811531	dM		$\cos \frac{1}{2} dL$ ar. co.	0.000000	
		A′	8.5094286	Corr.			—0.920177	
		$\cos L'$ ar. co.	0.0491616					
			1.2671436					
			″				″	
		dM	—18.499			—dZ	+8.32	
						2d Term		

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	South Base to Sage	167	40	08.03
L	Sage to Dick	61	40	59
Z	South Base to Dick	105	59	09.03
dZ		—	1	22.54
180		180	00	00
Z′	Dick to South Base	285	57	46.49

	°	′	″			°	′	″
L	26	42	45.927	South Base	M	113	34	33.163
dL	+		47.010	5,253.75 meters	dM	+	3	02.742
L′	26	43	32.937	Dick	M′	113	37	35.905

K		3.7204697	K^2	7.44094			h	—1.6722
cos Z		—9.4399637	$\sin^2 Z$	9.96574	(δL^2)	.....	$K^2 \sin^2 Z$	7.4067
B		8.5117844	C	1.10751	D	2.2968	E	5.8574
h		—1.6722178		8.51419		.....		—4.9363
		″						
1st Term		—47.013	3d Term	.....			dM^3	.....
2d Term		+ .003	—4th Term	.....			F	.....
		47.010		.....				.....
3d and 4th Terms		.....						
—dL		—47.010						
	°	′	″		Arg.		dM	+2.261838
λ	26	43	09.432	K	3.7204697	K	—0	sin λ 9.652845
				sin Z	+9.9828724	dM	0	$\cos \frac{1}{2}$ dL ar. co. 0.009000
				A′	8.5094291	Corr.	.....	+1.914683
				cos L′ ar. co.	0.0490664			
					2.2618376			
					″			″
				dM	+182.742		—dZ	+82.54
							2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Sage to South Base	347	39	42.82
L	South Base to North Base	23	18	23
Z	Sage to North Base	324	21	19.82
dZ		+		33.55
180		180	00	00
Z′	North Base to Sage	144	21	53.37

	°	′	″			°	′	″
L	26	46	35.700	Sage	M	113	35	29.162
dL	—	1	33.278	3,532.44 meters	dM	—	1	14.499
L′	26	45	02.422	North Base	M′	113	34	14.663

K		3.5480743	K^2	7.09615			h	
cos Z		+9.9099027	$\sin^2 Z$	9.53097	(δL^2)		$K^2 \sin^2 Z$	
B		8.5117806	C	1.10871	D		E	
h		+1.9697576		7.73583				
		″						
1st Term		+93.273	3d Term				dM^3	
2d Term		+ .005	−4th Term				F	
		93.278						
3d and 4th Terms								
−dL		+93.278						
	°	′	″		Arg.		dM	−1.872150
λ	26	45	44.061	K	3.5480743	K	sin λ	9.653492
				sin Z	−9.7654854	dM	$\cos \frac{1}{2}$ dL ar. co.	0.000000
				A′	8.5094286	Corr.		−1.525642
				cos L′ ar. co.	0.0491613			
					1.8721496			
					″			″
				dM	−74.499		−dL	−33.55
							2d Term	

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	Sage to South Base	347	39	42.82
L	South Base to Dick	44	12	32
Z	Sage to Dick	31	52	14.82
dZ		—		57.05
180		180	00	00
Z′	Dick to Sage	211	51	17.77

	°	′	″			°	′	″
L	26	46	35.700	Sage	M	113	35	29.162
dL	—	3	03.076	6,634.05 meters	dM	+	2	06.740
L′	26	43	32.624	Dick	M′	113	37	35.902

K	3.8217790	K²	7.64356			h		2.2626
cos Z	9.9290310	sin² Z	9.44528	(δL^2)	4.5252	K² sin² Z		7.0888
B	8.5117806	C	1.10871	D	2.2975	E		5.8584
h	2.2625906		8.19755		6.8227			5.0000
	″							
1st Term	+183.059	3d Term	.....			dM^3		.....
2d Term	+ .016	—4th Term	.....			F		.....
	183.075		.....					.....
3d and 4th Terms	+ .001							
—dL	+183.076							
	° ′ ″			Arg.		dM		+2.102913
λ	26 45 04.162	K	3.8217790	K	.....	sin λ		9.653325
		sin Z	+9.7226384	dM	.....	cos ½ dL ar. co.		0.000000
		A′	8.5094291	Corr.	.....			+1.756238
		cos L′ ar. co.	0.0490661					
			2.1029126					
			″					″
		dM	+126.740			—dZ		+57.05
						2d Term		.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	North Base to South Base	6	55	33.35
L	South Base to Dick	56	39	08
Z	North Base to Dick	63	34	41.35
dZ		—	1	30.56
180		180	00	00
Z′	Dick to North Base	243	33	10.79

	°	′	″			°	′	″
L	26	45	02.445	North Base	M	113	34	14.688
dL	—	1	29.854	6,211.90 meters	dM	+	3	21.282
L′	26	43	32.591	Dick	M′	113	37	35.970

K		3.7932246	K²	7.58645			h	.....
cos Z		9.6483373	sin² Z	9.90417	(δL²)	.....	K² sin² Z	.....
B		8.5117822	C	1.10823	D	2.2972	E	.....
h		+1.9533441		8.59885				.....
		″						
1st Term		+89.814	3d Term	.....			dM³	.....
2d Term		+ .040	—4th Term	.....			F	.....
		89.854						
3d and 4th Terms		0.000						
—dL		+89.854			Arg.		dM	+2.303806
	°	′ ″	K	3.7932246	K	.....	sin λ	9.653130
λ	26	44 17.518	sin Z	9.9520860	dM	.....	cos ½dL ar. co.	0.000010
			A′	8.5094291	Corr.	.....		+1.956946
			cos L′ ar. co.	0.0490660				
				+2.3038057				
				″				″
			dM	+201.282			—dZ	+90.56
							2d Term	.....

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	South Base to North Base	186	55	25.03
L	North Base to Obs. Spot	6	07	15.69
Z	South Base to Obs. Spot	193	02	40.72
dZ		+		1.71
180		180	00	00
Z′	Obs. Spot to South Base	13	02	42.43

	°	′	″			°	′	″
L	26	42	45.927	South Base	M	113	34	33.163
dL	+		14.758	466.21 meters	dM	—		3.807
L′	26	43	00.685	Obs. Spot	M′	113	34	29.356

K	2.6685846	K^2	5.33717			h		
cos Z	—9.9886457	$\sin^2 Z$	8.70710	(δL^2)		$K^2 \sin^2 L$		
B	8.5117844	C	1.10751	D		E		
h	—1.1690147		5.15178					
	″							
1st Term	—14.758	3d Term				dM^2		
2d Term		—4th Term				F		
3d and 4th Terms								
—dL	—14.758			Arg.		dM		—0.580597
	° ′ ″	K	2.6685847	K		sin λ		9.652527
λ	26 42 53.306	sin Z	—9.3535513	dM		$\cos \frac{1}{2}$ dL ar. co.		0.000000
		A′	8.5094293	Corr.				—0.233124
		cos L′ ar. co.	0.0490322					
			0.5805975					
			″					″
		dM	—3.807			—dZ		—1.71
						2d Term		

Computation of the latitudes, longitudes, and azimuths, etc.—Continued.

		°	′	″
Z	North Base to South Base	6	55	33.35
L	South Base to Obs. Spot		45	13.83
Z	North Base to Obs. Spot	6	10	19.52
dZ		—		6.61
180		180	00	00
Z′	Obs. Spot to North Base	186	10	12.91

	°	′	″			°	′	″
L	26	45	02.445	North Base	M	113	34	14.681
dL	—	2	02.046	3,778.46 meters	dM	+		14.698
L′	26	43	00.399	Obs. Spot	M′	113	34	29.379

K	3.5773145	K²	.....			h	.....
cos Z	+9.9974253	sin² Z	.....	(δL′)	.....	K² sin² Z	.....
B	8.5117822	C	.....	D	.....	F	.....
h	+2.0865220						
	″						
1st Term	+122.046	3d Term	.....			dM³	.....
2d Term	.....	—4th Term	.....			F	.....
	.....		.....				.....
3d and 4th Terms	.....						
—dL	+122.046						
	° ′ ″			Arg.	.....	dM	1.167245
λ	26 44 01.422	K	3.5773145	K	.....	sin λ	9.653063
		sin Z	+9.0314692	dM	.....	cos ½dL ar. co.	0.000000
		A′	8.5094293	Corr.	.....		0.820308
		cos L′ ar. co.	0.0490319				
			1.1672449				
			″				″
		dM	14.698			—dZ	+6.61
						2d Term	.00

In order to determine the topography of the country, the triangulation officer must "cut in" every point of any importance that may be visible from the triangulation stations, and faithful sketches with copious notes will be found invaluable in the final plotting. The tangents to all table-lands, lakes, directions of mountain ranges, ridges, mouths of cañons or rivers, and everything possible to obtain should be taken at each point to make it unnecessary to return. In cases where a mountain top has two points or more, "cut" upon all of them, making notes concerning it. These notes have saved many a long trip and consequent delay of the ship and the party.

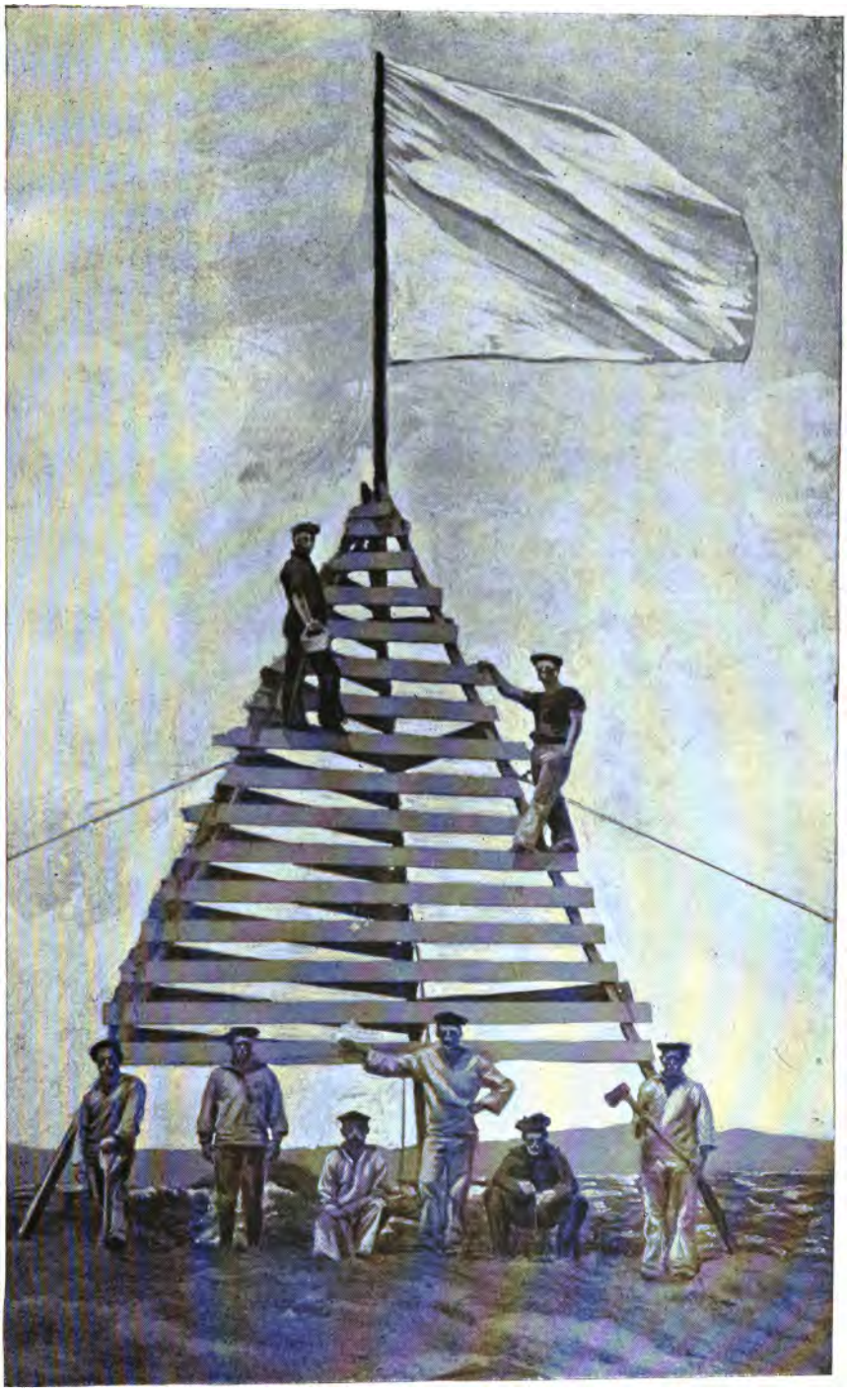
A good pocket aneroid barometer, having a graduated circle for elevation, was always carried on this work, and its readings carefully entered in the field book at any prominent point where a round of angles could be obtained. A rough sketch was also made at these points with copious notes. By this means a more accurate delineation of the topography of the country could be obtained, as the readings are carefully compared with the ship's mercurial barometer upon the return.

At each triangulation station after occupation, a cairn of stones, or whatever was obtainable, was erected, in the center of which was placed a bottle or can containing the record of work done at the station.

Specimen page of angles observed in the main triangulation.

[Place: Back of San Pablo Bay. Station occupied: Harris △. Date, November 18, 1889. Observer, Lieut. A. W. Lowry, U. S. Navy.]

Objects observed.	Angles.			Remarks.
	°	′	″	
Jack △	0	0	0	Misty, but pleasant weather.
Noble △	5	17	45	
High ⊙	31	11	00	Station on highest point of the nest of mountains back of San Pablo Bay. △ marked by a cairn of bushes and stones. Record in a tin can reads: U. S. S. *Ranger*, Nov. 18, 1889. Name of station: "Harris." Instrument, Fauth & Co., No. 204.
Summit △	32	34	45	
Medium ⊙	40	25	00	
Lower ⊙	46	15	15	
Low ⊙	52	25	00	
Fine ⊙	61	17	15	
Round ⊙	77	52	00	
Peak △	87	57	00	
Flat	96	27	00	
Top △	119	00	00	Highest point of a very distant range.
Cone	131	20	30	
Cone (2)	135	36	15	
Ballenas △	139	08	00	One of the "Loafs" from Lagoon Head.
Ballenas (1) ⊙	138	51	00	
Ballenas (2) ⊙	139	31	00	Called "Loaf" (2), P day.
Loaf △	141	08	00	
Rugged △	152	10	30	
Table △	157	26	00	

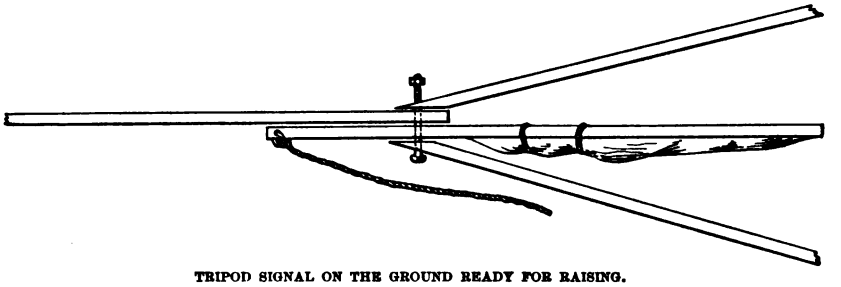


A MAIN TRIANGULATION SIGNAL.

THE MAIN TRIANGULATION PARTY PREPARED TO LEAVE THE SHIP FOR A WEEK'S TRIP, UPON WHICH LUMBER HAD TO BE CARRIED TO BUILD SIGNALS.

Specimen page of angles observed in the main triangulation—Continued.

Objects observed.	Angles.			Remarks.
	°	′	″	
Notch △	157	29	45	Distant table-land beyond Table △.
Asuncion Island △	180	13	00	
Asuncion Island K	177	42	00	
Asuncion Island ≻|	180	49	00	Called "San" in one or two cuts, ship's work.
San Roque Island (Middle) ("San")	192	08	00	
San Roque Island K	188	17	00	
San Roque Island ≻|	194	09	00	
Jack △	0	00	00	



TRIPOD SIGNAL ON THE GROUND READY FOR RAISING.

This structure consists of four scantlings, each 2 by 4 inches in cross section and 20 feet long. These are assembled, as indicated in the figure, by means of a half-inch bolt about 12 inches long and having a head at one end and a long thread and nut at the other. The sheeting for the flag, which is 9 feet square, is secured to the pole by rolling two laths in the edge and nailing them to one end of the flag pole, to the other end of which a tripping line 25 feet in length is secured, in order to raise the pole. If the three sides of the tripod are to be boarded, there will be required fifteen boards of an average length of 12 feet and 5 or 6 pounds of 10-penny nails. The implements needed are two hatchets, an ax, and a pick and shovel, together with brushes, buckets, and lime to whitewash the signal.

TO SECURE THE RAISED SIGNAL.

After raising the tripod, spread the legs evenly; then dig the holes and set the feet of the tripod in them. Next nail two short pieces of board to the sides of each heel, and lay a short piece of board each side forming a platform on which the dirt and stones are to be thrown. This makes a good anchor for the tripod.

Where high winds are to be expected guys from the head of the tripod, set up to stakes some distance away, are very useful.

The main triangulation party consisted, generally, of the officer and two men. Their outfit, divided equally as to weight, consisted of 1 gallon of water each (9 pounds), one haversack of provisions (4 to 10 pounds, according to time expected to be away), one blanket each, and two rubber blankets, with a piece of sheeting 3 yards wide by 5 yards long, and a strand of junk. The sheeting was frequently used as a tent, and was generally wrapped about the cairn or placed on a pole in the cairn as a flag on leaving the station. In addition to this the theodolite and tripod were carried. On a trip lasting several days this outfit amounted to about 40 to 45 pounds per person. When landing on the beach for any protracted period, an extra precaution was taken to cache a certain amount of provisions and water and, at times, a good tent, to which the party might make their way and remain comfortably for several days in case of bad weather and inability to get on shipboard.

The reflecting glass of a small heliotrope was also often carried and was used to signal the ship on a prearranged system. A system of signaling by fires was also adopted, by which, when the party reached the beach after dark, it would be known whether they were desirous of coming on board or would be comfortable on shore.

The following report, made by Lieut. O. W. Lowry, U. S. Navy, immediately after his occupation of the triangulation station known as Peak, gives a full account of the outfit which is needed for such work and of the difficulties which are to be encountered:

U. S. S. RANGER,
ASUNCION BAY, LOWER CALIFORNIA,
December 8, 1889.

SIR: In compliance with your request I herewith submit a detailed report of all the incidents which occurred during my recent trip to "Peak" triangulation point.

I left the ship at 5:45 a. m., December 3, with my party of five men. Two of the men were only to accompany me until noon, for the purpose of carrying extra water and provisions to some point inland, where I would cache the reserve supply and from there start for the peak with water and provision sufficient for a few days' supply.

Eight canteens, each holding 1 gallon of water, had been filled the evening before starting, and, in addition to the water and provisions, each of the party took his blanket. Two rubber blankets, the theodolite, tripod, barometer, and angle books made a weight which, when evenly divided, gave each of the party about 23 pounds to carry.

Upon landing it was discovered that one canteen was leaky, owing to a faulty screw cap, and another had evidently been sampled by some thirsty person during the night, as it was but two-thirds full. There was no time to correct these defects, however, so we divided our load equally and pushed on.

From the landing to the peak, in a straight line, is 16¾ miles, but owing to the conformation of the country the route traveled was probably increased to 20 or 21 miles, with an ascent of 3,100 feet.

For the first 4 miles the walking was fairly good, being generally level, with here and there a ravine from 30 to 60 feet deep, to reach the bottom of which was found to be far more easy than to climb out again; but we kept together, laughing at little mishaps, such as tumbles, brushing against cactus, etc., and made an average of about 2 miles per hour, with a rest of ten minutes during each hour.

For the next 5 miles the walking was difficult, being over masses of broken rocks lying in all conceivable positions.

Coarse sagebrush growing between the rocks at times completely hid them from view, and to pick one's steps was at times impossible; owing to this fact these 5 miles gave most of us a number of falls, with the accompaniment of scratched hands, torn clothes, and bruised knees and ankles.

We stopped at the mouth of a cañon about 7 miles from the landing, up which I had decided to go, and as it was then after 11 a. m., and we were all quite worn out, I decided to take a rest, get our dinner, cache the provisions, and send the two extra men back to the ship. This was done, and at noon the two men started on their return trip. At 12:10 p. m. we reapportioned the weight to be carried, having thus far consumed 1 gallon of water, including what was given to the two men for their return.

Each man was directed to take in his haversack enough food to last him for four days and cache the remainder. We also left one canteen of water, and with the remaining five canteens we continued our journey, my intention being to consume but 1 gallon of water during the remainder of the trip to the peak, which would leave

THE MAIN TRIANGULATION PARTY OCCUPYING THE STATION AT LAGOON HEAD.
The stakes shown to the left are those used to mount the heliotrope, constructed out of gas pipe and a large state-room mirror. By means of this instrument flashes were thrown to Cerros △, lying 60 miles to the westward of Lagoon Head.

us 5 gallons to subsist upon for the four days there and still have enough left for the return trip to the cache.

The day was excessively hot, and for the next 3 miles the walking was of the worst possible description, until we were well along upon a table-topped ridge, when we left the stones behind and began to make good speed again through a sandy plain covered with sagebrush, elephant trees, and many varieties of cactus; but by carefully picking our way we avoided the thorns of the latter and by nightfall had made a good stretch on our journey. Darkness found us on this ridge about 7 miles from the peak, so we dropped our load, and after a few minutes' rest gathered wood and made a fire. I then made 1 pint of coffee, which we divided equally, and after a light supper we rolled into our blankets and had a tolerable night's rest.

At 4:30 a. m. we turned out, and upon making a fire to prepare another pint of coffee I found that by some unaccountable means the water had all "evaporated" from the canteen we had been using, leaving us but four canteens and still 7 miles from the mountain. There being no means of learning who the culprit was, I accepted the result, said but little, and ordered *no* coffee. I then gave each man half a cup of water, took the same myself, and when we had finished a light breakfast we pushed on.

I took three canteens, gave the other two to another man whom I kept by me all the time, and directed that no more water should be drank until the mountain was reached. As soon as it was light enough to avoid the cactus thorns we started, and after a walk of 2 miles we descended to a plain having numerous valleys, all leading from the mountain range to San Cristobal Bay. By 7 a. m. we were feeling the effects of thirst very severely, when we came to a halt near several bunches of cactus called mescal. One of my men and myself had eaten of this on previous tramps, so we cut them down and sucked the juice from the butt of the leaves, finding the flavor not at all unpleasant; in fact it has scarcely any taste, and relieved our thirst very materially. The weather had been cloudy all the morning, and about 8:30 a. m. a light shower of rain began to fall. Instantly the rubber blankets were spread upon the ground to catch the water, but the fall was so light that none could be caught just then, so I left two men with the blankets, giving them instructions to catch and save all the water they could, and if the rain ceased to come to the mountain; but at any rate to be at the mountain by sunset (about 4:45 p. m.), while the remaining man and myself went on, carrying all the water, the theodolite, tripod, and our two haversacks. We reached the base of the peak at about 10:20 a. m. The mountain was enveloped in a fog fully halfway down, and as there was no need for further hurry we dropped our load, and being nearly choked from thirst we started up the cañon searching for holes on the rocks in which a mouthful or even a sup of water might be found. In this we were quite successful and managed to get perhaps half a pint each during a climb of about 600 feet and return, as a drizzling rain was falling continuously.

We were wet through with perspiration, and what rain fell could not affect us in that respect. Upon my return down the cañon, I found the only place we discovered during our stay on the mountain where there was sufficient ground for four persons to lie down at once. It was close by a large bowlder some 15 feet high and as much in diameter, so we carried our load up to it and then began gathering brush and odd limbs to make a fire when night should come. This kept us busy most of the afternoon, and at 4 p. m., seeing the fog shutting down on the plain and having heard nothing of the two men left behind, we both went down to the mouth of the cañon and took turns calling and whistling to get a response. At 4:40 the sound of voices and the click of tramping sticks greeted us from the fog below. We continued hallooing, but at 5:30 no further sounds could be heard, so we separated, each taking one side of the cañon and continuing to hail. I then fired my revolver at intervals, and shortly after heard a hail well off to one side of the mountain, the men having been misled. I sent off my man in that direction to hail, while I continued

firing, and about 7 p. m. I was gratified to hear their voices much nearer. In response to my hail of inquiry came the reply, "Got lost, but all right now." At 7:30 p. m. we all reached the camp, the two men having caught and brought with them 1½ gallons of water in addition to what they had drank. Each cupful as it had been caught was strained through sheeting, as the high wind had covered the blankets with sand and rubbish, and, although still somewhat muddy and with a flavor of rubber, it was highly appreciated and did us good service later on for making our scanty allowance of coffee as well as for drinking. That night, while drying our clothes around the campfire, I took an inventory of all the provisions and made a startling discovery. Two of my men were in the same mess on shipboard, and upon packing their haversack at the place where provisions were cached a scanty allowance for *one* man was all that had been put in the haversack for two, so that but four hard-tack and one small can each of oysters and clams were all that remained for them for four days.

When I learned this I at once decided, from the appearance of the weather and the possibility of my being detained at the peak for even more than four days, it was of the utmost importance for the success of my observations that I should reduce the consumption of food and water to a minimum, so I told two of the men to be ready to return to the ship on the following morning. We were up at 4:30 a. m.; made 1½ pints of coffee; gave the extra half pint to the men who were to return, and after a fair breakfast of hard-tack, corned beef, and coffee, I gave each man one hard-tack and 1 quart of water to use on the way. Each took his blanket, with one rubber blanket, in case they should not be able to reach the ship by night. I told them to make a good meal at the cache, and if they needed it they might take half the canteen of water which was there. By this time we were all complaining of sore lips, and I found it due to the poison from the cactus we had eaten. Each one's lips had large watery blisters, and our tongues a smarting sensation. The two men left us at 7 a. m., saying they would surely be able to reach the ship by sunset; and I have since learned they reached the beach by 6 p. m. and were soon on board, having scarcely touched the water and provisions at the cache. When they had left, the mountain still being in fog, I took an inventory of the provisions and found we had 3½ gallons of water, ten hard-tack, one 1-pound tin canned chicken, one 1-pound tin corned beef, one tin sardines, and one 1-pound tin clams; but as there were but two of us left, and not much work to do, we at once went on diminished rations, limiting ourselves to one-quarter pint of coffee at supper and breakfast, one tin of provisions for the day, and half a hard-tack each per meal.

The camp was about 800 feet below the summit, where four cañons centered, and each trip up and down we took a different route to prospect for water, and when found it would be dipped out with a spoon and poured into the coffeepot which was carried along for that purpose. On the 5th instant, the day the two men returned, there was much fog until about 3:30 p.m. when I got a cut on Cerros Island △, and before sunset I had completed more than half the points I wished to cut upon.

I waited at the summit a trifle too long, however, for safety, for on my return to camp it grew very dark and as the walking was very difficult even in daylight it was much more so by dark, and I had several narrow escapes, getting but one real tumble, which resulted in a severe bruise to my elbow and a number of scratches. I was happy over the result of the day's work, however, and hopeful of getting a cut on Lagoon Head △, 52 miles away, with the mists all around it, but not reaching its top. I was only able to get two cuts on it before it was hidden in the mists, but I was satisfied. The remainder of the day, until 12:30 p. m., was spent cutting upon other points, and at that time, everything being completed, we built a cairn of stones in which the record was placed, and piled trunks of elephant trees upon and around it, then came down to the camp with happy hearts at the prospects of a good meal within a reasonable time, and at 1:20 p. m. we were packed up and on our way home. By 2 p. m. the weather looked threatening and the prospect of being left on the

THE MAIN TRIANGULATION PARTY REACHING THE BEACH AT CERROS ISLAND AFTER HAVING WAITED AT THE SUMMIT SIX DAYS TO OBTAIN CUTS ON LAGOON HEAD AND OTHER STATIONS ON THE MAINLAND.

Two wild goats, shot in the mountains, are shown in the illustration.

beach for several days while the ship ran for shelter in a southeaster seemed most favorable, but we hurried along, the perspiration streaming from every pore, until 3 p. m. when the wind came in a gust from south, accompanied by a heavy rain.

We ran to an elephant tree for shelter, cut off the lower branches, and by tying the corners of the rubber blanket to the under side of the branches managed to get under it and keep fairly dry, besides catching nearly a gallon of water.

This squall lasted forty minutes and I was undecided whether to push on or not, but finally decided to do so. We lashed up again and walked until dark, when a drizzling rain set in, lasting nearly an hour, and we camped as before, under another elephant tree, but about 4 miles nearer home. That night we were happy. Had a whole hard-tack each for supper, and a can of sardines between us, with all the coffee we wanted; and in addition we had three more hard-tack and a can of boned chicken left, of which we ate all but the one hard-tack for our breakfast, with plenty of coffee.

Left that place at 5:40 a. m. on the 7th instant and at 7 a. m. stopped on the ridge, from which we had our first view of the ship, and built a large fire. From there, after a hard tramp over the stones and brush, we reached our cache at 10:20 a. m. where we remained for an hour, had all the luxuries the cache afforded, and at 11:30 a. m. left there with a little luncheon, in case of accident, and as we crossed the last ravine, about 2 miles from the ship, we took our last swallow of water, having had all we needed for two days past. We reached the ship safely after an absence of 105½ hours. Not a particle of vegetation was seen during the trip, except elephant trees, sagebrush, and many varieties of cactus. No water was found except what little had fallen during the rain.

Five deer and perhaps fifty jack rabbits were seen, the latter being most numerous about 10 miles inland, in the cañons leading up to the mountain range.

In concluding this report, I wish to call your attention to the provisions furnished the men who form the tramping parties, and see if some means can not be devised to furnish them with a variety of more nourishing food. In a tramping party, especially on main triangulation duty, I am absent at times for several days, with no means of preparing any food. The food carried must be already cooked and canned and put up in small tins.

The messes on board ship carry nothing in tins but oysters, clams, sardines, and corned beef. The two first named have not sufficient nutriment to compensate for their weight, and the corned beef they have is in either 2 or 4 pound tins. When these are opened on a tramp the whole amount can not be eaten at one meal, and if carried open in a haversack the heat of the sun and the frequent capsizing of the haversack causes the grease to run over everything.

It should be in tins of 1-pound size. Sardines are good in that they are nourishing, not salty, and the oil they contain makes hard-tack much easier to masticate. Hard-tack is the only kind of bread that should be carried. It would be much better for the men, however, if a reasonable amount of lunch tongues, canned chicken, and beef extract could be furnished them, to give more variety to their diet.

Very respectfully,

O. W. LOWRY,
Lieutenant U. S. Navy, in Charge Main Triangulation.

Lieut. Commander GEO. C. REITER, U. S. Navy,
Commanding U. S. S. Ranger.

CHAPTER II.

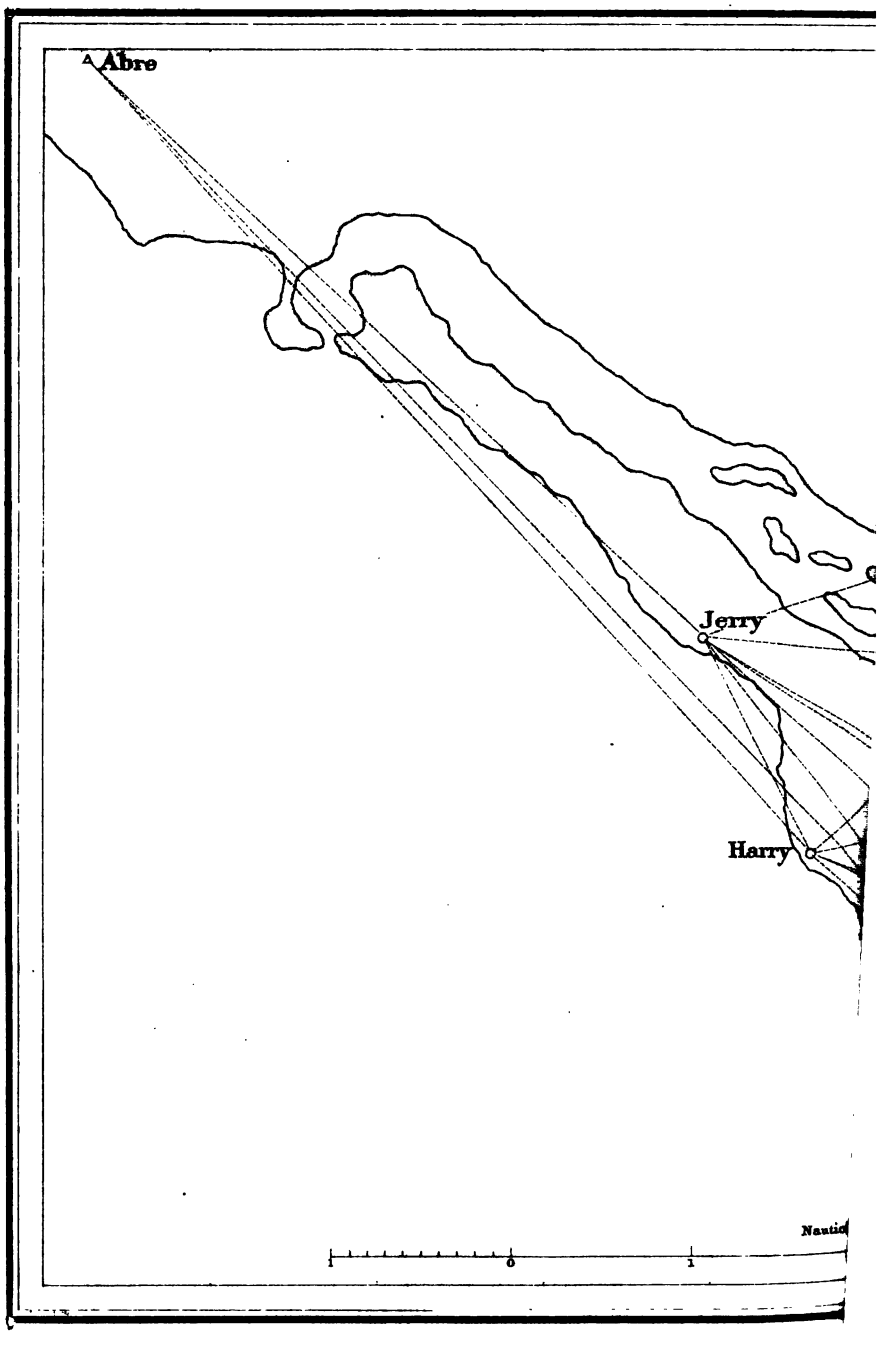
THE SECONDARY OR SHORE TRIANGULATION.

The secondary triangulation was carried on conjointly with the main triangulation and consisted in connecting the shore and boat signal and the outlying rocks and islands with one another and with the stations of the main triangulations. Signals were erected at prominent points and were fixed by angles taken with a Bureau theodolite. When the configuration of the coast was such as to admit of a favorable distribution of signals, they were connected by a train of secondary triangles as represented by dotted lines in the accompanying illustration of the coast line between Point Eugenio and San Bartholmé Bay. But when long, straight stretches of coast occurred the positions of the signals were fixed by rounds of angles upon one another and the stations of the main triangulations, as shown in the accompanying sketch of the shore line in the vicinity of Abrejos Point. The depths and limits of bights, the positions and extent of outlying points and rocks, and the general direction of the coast were obtained by the requisite cuts, while by means of measured distances and offsets and sketches of the coast and the adjacent country the shore line and topography were delineated. The sketches were afterwards drawn in smooth form by the secondary triangulator. The accompanying illustration is a reproduction of the smooth sketch, on the scale of one inch to the nautical mile, of the portion of the shore line lying between Point Eugenio and San Bartolomé Bay, and will show the manner in which this part of the work was prepared to be incorporated into the smooth plotting sheet.

Wreckage found on the beaches, with sheeting provided by the ships, and such brushwood as could be gathered, generally formed the signals for this work, as there is a notable absence of trees or timber of any size in this part of the country. The smooth sheet furnished by the main triangulator was continually being reproduced, on varying scales, to be used in the secondary triangulation. Upon these sheets all the positions determined by the secondary triangulation were cut in and the coast line drawn. They were then used by the boat officers in the hydrography.

The officers of the main and secondary triangulation conferred with each other frequently concerning the work, and a mutual understanding of what points had been determined by each served greatly to facilitate the determination of the various points on shore and in the interior, each party knowing what angles the other desired to obtain.

Experience showed that in running in the shore line the triangulation officer should have at least three men with him, one of these to record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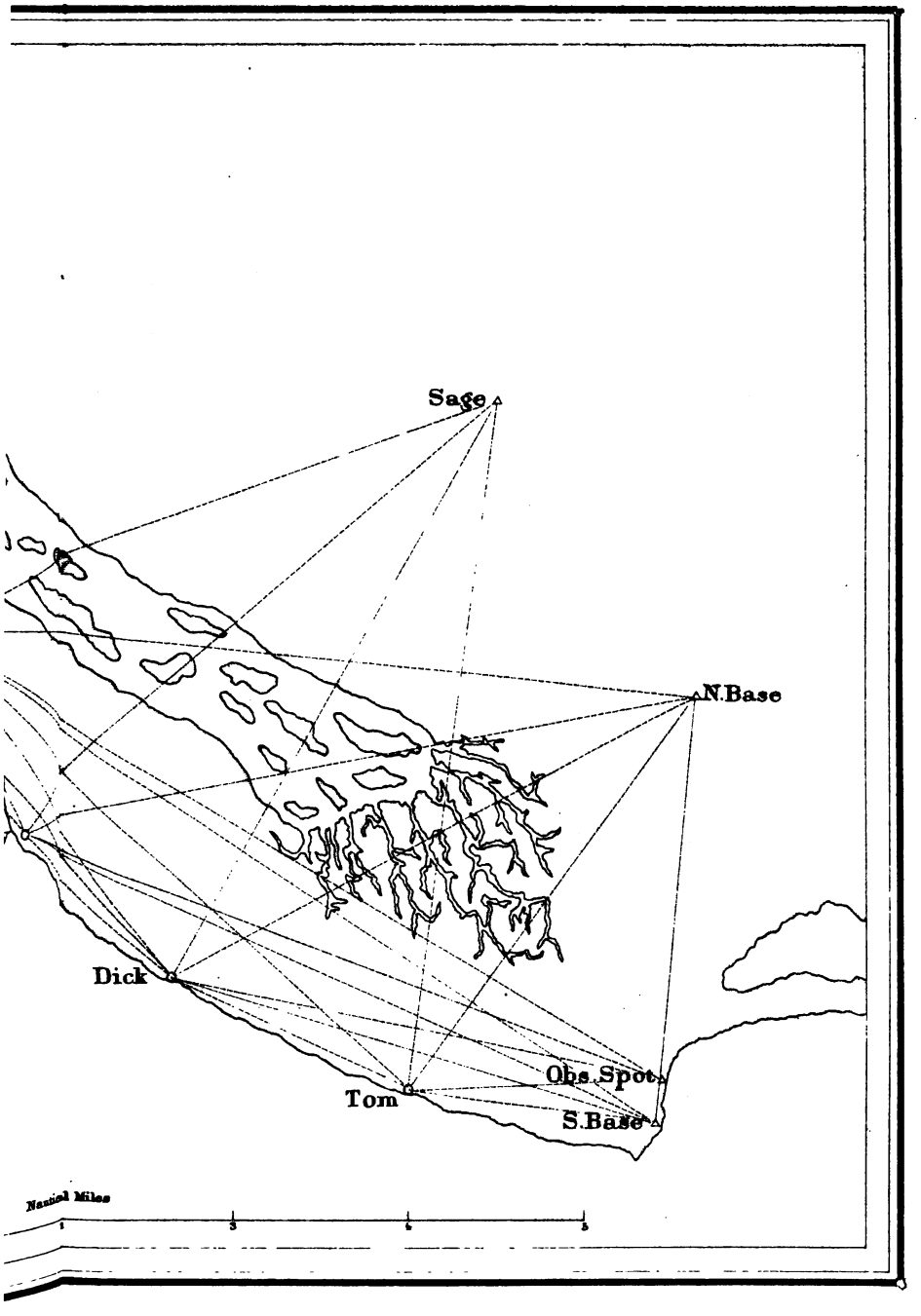
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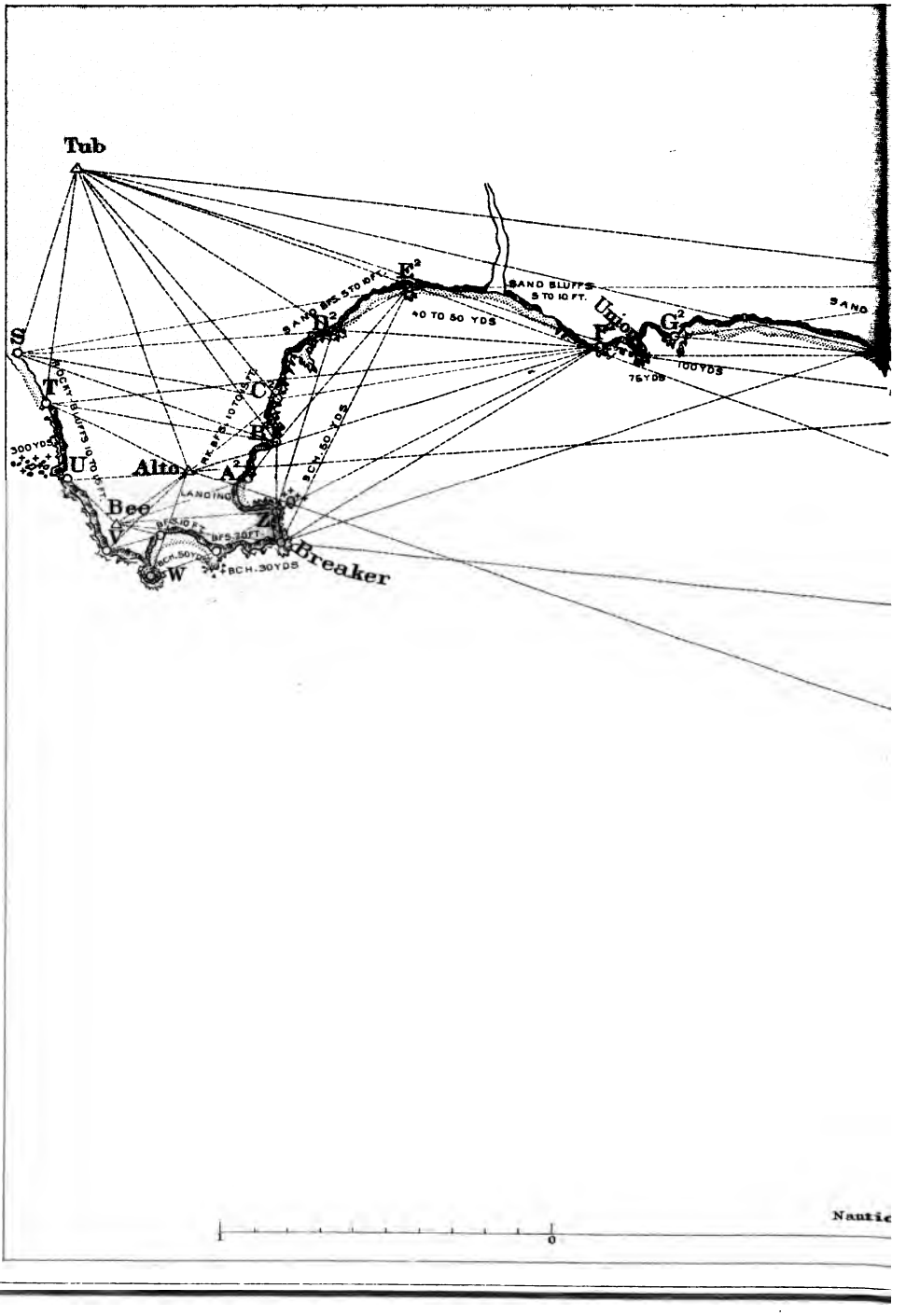
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SAND BLUFFS 5 TO 10 FT.
40 TO 50 YDS
SAND
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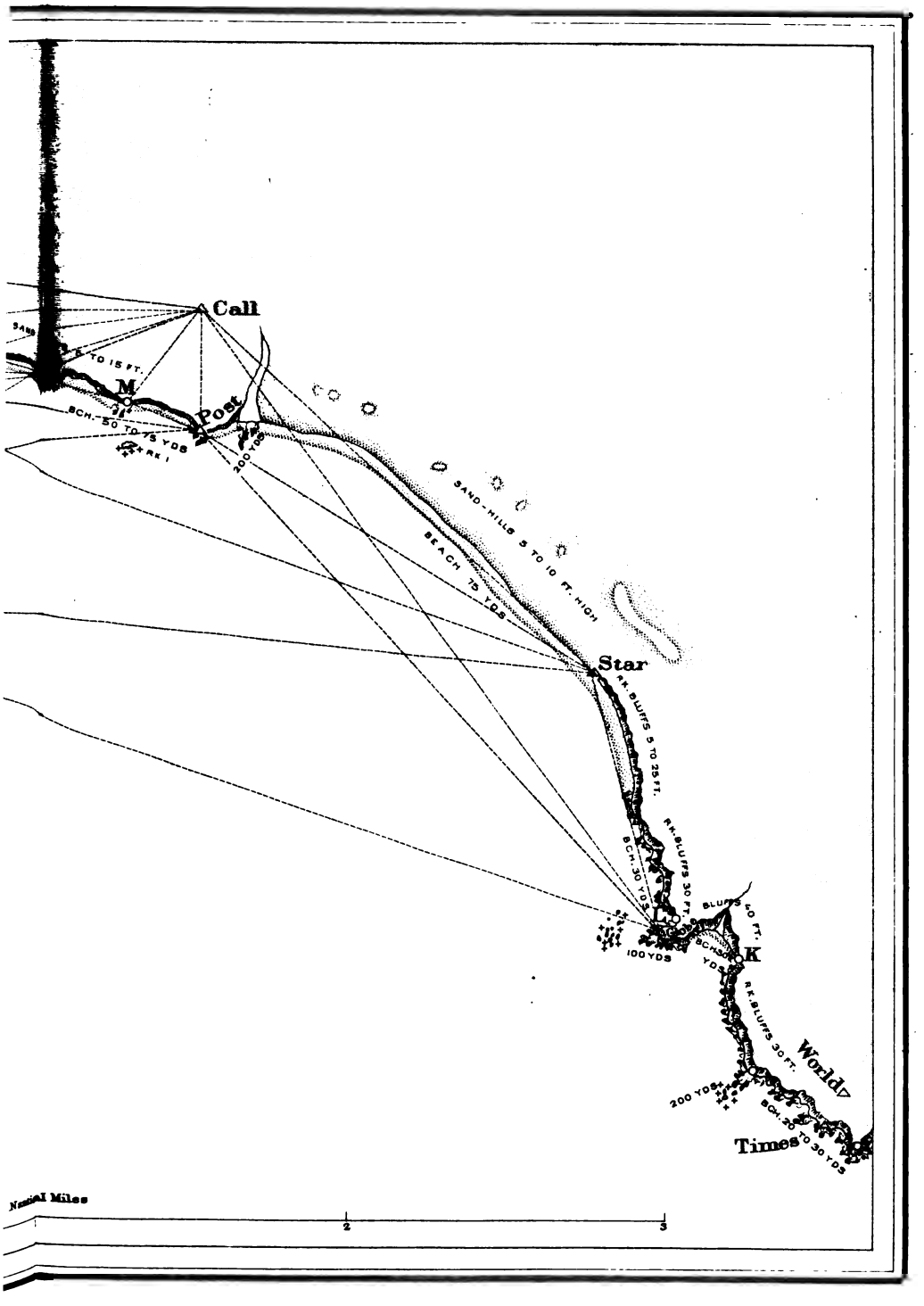
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RK.-BLUFFS 5 TO 25 FT.
RK.-BLUFFS 30 FT.
BCH.-30 YDS
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Nautical Miles
1
2
3

EMBARKING IN THE SURF.

the angles and to make sketches, and the other two men to go in advance to erect signals on the selected points. Each man carried his haversack containing his provisions and canteen of water, a supply of rope yarns, and a roll of ten or fifteen yards of sheeting. At times a hatchet and some nails were also carried, but these matters of detail were subject to change at various stretches of the coast. At places where landing was difficult protracted journeys had to be made, and in these cases water and provisions were landed and the articles needed to carry on the work were carried in extra amount.

Specimen page of angles observed in the secondary triangulation.

[Place: Near Port San Bartolomé. Station occupied: Thurloe. Date: November 20, 1889. Observer: Lieut. W. F. Halsey.]

Objects observed.	Angles.			Remarks.
	°	′	″	
S. Mist ⊙	356	37	30	See Reoccupation, page 7, book 5.
United △	338	46	00	
D^3 △	332	04	00	
C^3 ⊙	278	46	00	
Head △	231	27	00	
A^3 ⊙	171	57	00	
United △	338	46	00	
S. Mist (2) ⊙	1	08	00	
Tang. Bight between Head and C^3	236	15	00	
Tang. to Head	237	54	00	
Direction reef of C^3	274	39	00	
Nest rocks off A^4:				
Rtang same	135	22	00	
Ltang same	130	35	00	

During the season of 1889 and 1890 the secondary triangulation was carried on by Lieut. W. F. Halsey, U. S. Navy. He began work at San Pablo Bay on the 18th of November, 1889, and continued at intervals until the 6th of March, 1890, when the entire coast between San Bartolomé Bay and Ballenas Bay had been triangulated. The entire distance was walked over, except a short stretch in San Cristobal Bay, where the steepness of the coast and the rugged character of the country were such as to prevent the employment of the ordinary method. In this part natural signals were cut in from the ship and the shore line was sketched from the surf boat, pulling as near the coast as the state of the sea would permit. The length of the coast line surveyed during the season is 130 miles.

The following summary shows the work performed during the period referred to:

Points occupied	86
Points fixed	125
Distance traveled	327 miles.
Time away	270 hours.
Average number in party	5
Horizontal angles	1,478
Signals erected	102

CHAPTER III.

HYDROGRAPHY.

Hydrographic work in marine surveying includes the developing of the contours of the bottoms of bodies of water by lines of soundings and the observing of the set and strength of currents, the rise and fall of tides, and the direction, force, and periods of prevailing winds and recurring storms.

Through valuable assistance and notes contributed by Lieut. U. R. Harris and Ensigns J. M. Ellicott and C. M. Knepper, U. S. Navy, the methods of conducting this branch of a survey are here described as practiced by the officers of the *Ranger*.

SECTION I.

BOAT SIGNALS.

We will suppose the main triangulation complete and the chief of a hydrographic party in possession of sheets covering the body of water to be surveyed and having upon them the main triangulation points correctly plotted, together with all other points that have been accurately cut in from them. These points are seldom sufficient in number or so disposed as to be adequate for signals by which to fix the position of a sounding at any point on the sheet. It is necessary, therefore, first to establish and accurately to fix a great number of signals along the shore at places situated favorably alike for the determination of the outline of the chart and for the accurate and convenient working of those engaged in boat work. An observer must therefore be landed with a party of men well equipped for this purpose. The party should be made up as follows:

(1) An observer familiar with the use of theodolite and sextant or plane table.

(2) Three or four assistants who are used to handling axes and shovels, one or more of whom is good at carpentering, and one of whom can keep a correct record of observations taken and make useful sketches from point to point showing the character and outline of the shore and the topography adjacent to it.

The necessary outfit comprises: One small theodolite and tripod, one blank book for recording angles, making sketches, and noting miscellaneous items, one hatchet, one hammer, one ax, nails, one machete (if underbrush is to be encountered), one spade, a supply of rope yarns

and marline, a supply of sheeting, and a bucket of whitewash and a whitewash brush.

The question of good water and tent outfit must be left to discretion, guided by the character of the country, the length of time the party will remain ashore, the weather to be expected, and perhaps other things. One suggestion alone may be made here. If the country is infested with poisonous reptiles and insects, a tourniquet, a phial of ammonia, and a supply of whisky should be provided.

From a careful inspection of the country from the ship's deck the chief of the shore party should note, upon starting on his way, all natural or constructed objects suitable for signals, such as isolated houses, chimneys, steeples, cupolas, flagstaffs, beacons, prominent trees, hillocks, rocks, cactus stalks, discolorations, and landslides. To aid him in this the ship should be steamed as near the shore as possible, without risk, over the whole stretch that is to be signaled off in the single trip. Should there be time enough such a reconnoissance of the whole country to be covered during the season ought to be made before doing any work.

The chief of shore party is thus enabled to make a fairly close estimate of the number of artificial signals he must build and then of the amount of sheeting and whitewash to take with him. As a guide, it may be stated that an area of sheeting or whitewash 10 feet square on a dark background can be seen on a clear day about 4 miles, and, when it reflects the sunlight, much farther.

(1) When flying as a flag, if the background is the sea or sky, the sheeting should be *red* or *black*.

(2) In a trend of shore line free from sharp turns and bights the signals should not be more than 1½ miles apart.

(3) There should be a signal on every promontory and at the bottom of every bight.

(4) Whitewash, though cumbersome to carry, will last on a rock, board, or metal surface more than a year, while sheeting blows away or is stolen in a few weeks.

The chief of shore party should also note stretches of shore line where, because of precipitous bluffs, lagoons, or marshes, it would be necessary to have a boat to proceed and make arrangements accordingly. Before leaving for the beach he should also make sure that he is familiar with all signals of communication. Once landed he must proceed with his work, guided by the following considerations:

(1) His work must be connected up accurately with the main triangulation. He must, therefore, construct and occupy many of his signals with a view to well-conditioned triangulation and get all possible cuts on the stations of the main triangulation.

(2) His signals must be visible from the immediate shore line, both to enable him to cut in the shore line from them and to make them available for boats sounding near the shore.

(3) Sheeting signals are quickly built by wrapping the sheeting around a cluster of stalks or a large bush, by spreading it and pegging it down on the steep slope of a hillside, or by hanging it like an apron over the edge of a shelf, having it weighted with stones at the lower part to keep it from blowing about. Sheeting is more easily seen thus than as a flag flying from a pole.

(4) Do not place signals too close to the water's edge.

(5) Sheeting should be spread so as to reflect as much sunlight as possible in the direction from which it is to be seen.

It seems valuable to suggest, although the plan does not appear to have been tried, that if a surveying ship were supplied with, say, a a dozen polished metal spheres about a foot in diameter which could be mounted on poles as signals and continually shifted along from the finished end of the work, they would prove the best possible signals. Sheeting, or whitewashed scantling, or barrels could be attached to the poles below the spheres, to be used in dark weather when there is no reflected light. A little putty and a rag taken along by the shifting parties would soon remove tarnish.

(6) In cutting in a noticeable landslide or discoloration to be used for a signal some sharp corner of it or the topmost point should be used and a note made of it.

(7) In starting a line of soundings from the shore in a boat it is sometimes necessary, in order to get the course, to plot a series of positions as quickly as possible, but often, because of the nearness of the signals, the scale of the boat sheet throws them under the central framework of the protractor, and the delay in plotting makes the line a random one. Should, therefore, a point be reached in establishing signals where no stations of the main triangulation can be seen, it is better to place the signal about a quarter of a mile from the beach. The precaution will save the boat officer much exasperation and poor work.

In large basins, where lines are to be close together, additional signals can be established in the water where its depth is not too great. To do this take a pole whose length must be 6 feet, plus the depth of water, plus the height desired for the signal above water, and lash to its lower part a piece of gas pipe whose length is 6 feet, plus the depth of water. Secure the signal (barrel, or sheeting, or both) to the upper end of the pole, launch it, and steady it vertically alongside the ship or boat with its base on the bottom. Secure a section of hose over the upper end of the gas pipe and, having coupled the other end of the hose to a force-pump, force a stream of water through the hose and gas pipe, and the pole with the pipe will settle, almost unaided, into the bottom. When the upper end of the pipe is nearly down to the water's edge, stop the pump and take the hose from the pipe. In this manner any number of signals can be established rapidly. Both black and white objects or sheeting should be attached to these poles, for the background will from some points be light and from others dark.

Signals should have short, simple names, in some way describing the signal itself. It enables a boat officer to find them promptly and the recorder to record them quickly and correctly.

Therefore:

(1) If the station has a well-known name, select the characteristic syllable of that name for the signal, as, for instance, for Fort Wadsworth, write Wad; for Centennial Tower, Cent; for Lagoon Head, Goon.

(2) If it is a natural object, name it with a single syllable descriptive of its shape, color, or material. If it is a peak, for instance, name it round, sharp, cone, needle, blunt, more according to shape; if a tree or shrub, name it oak, pine, elm, sage, cactus, bush; if there is a discolorate, name it red, black, white, snow.

(3) Artificial signals having no particular characteristic should be named from the location, as, point, marsh, mouth, spit, bight.

(4) Avoid naming by numbers, letters, or proper names, for such a system is no help to the observer using them and may produce great confusion in the record.

All the work done by the shore party should be recorded neatly in a book, which, to distinguish it from other books of record, might well be called the "Shore Book." For reference it should be labeled on the outside and the pages should be ruled off and headed.

SECTION II.

BOAT SHEETS.

The next step is to prepare the boat sheets. The main triangulation adjacent to the stretch of shore line signaled off, plotted on an enlarged scale suitable for the boat-work, should be ready for the secondary triangulator when he returns to the ship. On this he plots the signals he has established, and these, together with other points of the main triangulation, not so distant as to make the sheet cumbersome, should be transferred to another sheet which, when the shore line has been sketched in, is the boat sheet.

A boat sheet should be laid out on stiff brown drawing paper of a light coffee color. White paper should *never* be used, for the glare from it is almost unendurable to the plotter and ruinous to the eyesight. If a boat officer is furnished with a white sheet, he should before using it, pour a cup of coffee evenly cover its whole surface and let it dry in.

If the plotting of the main triangulation is not sufficiently advanced to be used in plotting the boat-signals, the shore observer can assume an arbitrary scale and plot his work as independent triangulation. All work on such a sheet would be relatively correct, and could be reduced to the exact scale and azimuth when the main triangulation was completed.

In deciding upon a scale for the boat sheet the following points must be considered:

(1) The distance between adjacent lines of soundings.

(2) The number of soundings which must be plotted within a given length of line.

(3) The available space for the sheet in the boat.

A scale which leaves a half of an inch of space between any two adjacent lines of soundings is a very good scale to work upon. Larger scales are always better, both for increased accuracy and quick plotting, until the scale becomes so great that the sheet is cumbersome or the signals can not be reached by the arms of the protractor.

A boat sheet ready for use should contain:

(1) All shore and water signals, correctly plotted, in small circumferences of ink.

(2) All points of the main triangulation within the limits of the sheet in circumferences noticeably heavier than those marking shore and water signals.

(3) The circumferences marking points *occupied* both in the main and shore triangulation should contain inscribed triangles. The two branches of the work were distinguished by the shade of ink used; in main triangulation, black; shore triangulation, red.

(4) In *lead pencil* the outline of the shore from the shore book sketch,

(5) The approximate positions of low-water bars, sunken rocks, reefs. wrecks, and heavy breakers as established by the secondary triangulation should be outlined and described in pencil.

(6) A short note, *in pencil* abreast each signal on the *inshore* side describing it and its location, as: "White sheeting on bluff," "Red flag on pole," "Southeast gable of house," or "First tree below river mouth."

(7) Any signal whose accuracy is uncertain should be so marked in pencil.

(8) A compass-rose, *in ink* on the land side of the shore line near the center of the sheet marked to quarter points.

(9) A scale of miles and tenths, or smaller fraction according to the sounding intervals, *in ink* near the *upper* margin of the sheet.

(10) Any portion already sounded and not to be sounded out again should be outlined *in ink*. The outlines in pencil can be rubbed out and traced in accurately by the boat officer as the work develops them. The notes in pencil, being only for his guidance, can be rubbed out as the points are passed and become known to him.

The sheet should be fastened by thumb-tacks (*not pasted*) on a seasoned piece of portable white pine board of convenient size for the boat, having a canvass apron cover weighted with a lead strip in the hem attached to its upper edge. If they are pasted at the edges they will puff up in the middle when wet, but with tacks this looseness can be taken up by spreading the sheet anew.

STEAM LAUNCH AT WORK.

SECTION III.

LAYING OUT THE WORK.

The prepared boat sheet should now be ruled off lightly in pencil with the lines to be run. The chief of the party, in determining their direction and distance apart, should be governed by the following considerations:

(1) A channel or shoal is best developed by lines crossing it at right angles to its axis.

(2) An obstruction should be developed by more than one system of lines, say by radials and parallels or by two systems of parallels at right angles.

(3) The distance between lines depends upon the frequency of soundings, and this upon the commercial importance of the area surveyed, the foulness of the bottom, and tortuousness of the channels. In an important harbor, such as New York, lines of soundings should not be more than 200 yards apart. These should be crossed at right angles by another similar system, and, besides these two systems, shoals and obstructions should be developed by still other systems suited to these particular locations, and lines should be run on all channel ranges.

In open coast work one system of lines, normal to the general trend of the coast, is sufficient. These should be run one-half a mile apart by the launches or open boats from the shore to 3 miles out, or more if for any reason it is deemed unsafe for the ship to work in to that limit; and by the ship 1 mile apart from this limit until a depth of 100 fathoms of water is obtained. Crossing this system by any lines, except to develop a foul bottom, is unnecessary, for, owing to the ocean swell, the soundings often will not check within a fathom or more, and the result is useless perplexity and loss of confidence in the work done. In harbors the soundings taken on different systems should, after tidal corrections are applied, check within a foot.

In narrow and tortuous streams or lagoons in which the channels and shoals are little known the laying out should be left to the discretion of the boat officer. If there is a strong current, a system of zigzag lines carried up to the head waters and a midchannel line, or another system of ziz-zag lines brought back, constitute a good scheme.

SECTION IV.

STEAM LAUNCHES AND THEIR CREWS.

The steam launches used were better sea boats than the ordinary Navy launches, which, for work on open coasts, are not desirable. They had double condensing engines with keel condensers, and were fitted with air tanks forward and aft, besides a turtle-back forward, which extended their capability for running into a head sea. The improvements suggested by experience are a higher free board, a protection

to the condenser in the form of bilge keels, an increased capacity of the water tanks, and a more rigid mount for the compass. The composition and duties of a launch's crew were as follows:

Crew.	Duties.
Senior officer	Observer and in general charge.
Junior officer	Observer and in plotting.
Coxswain	Helmsman and general lookout.
Recorder	In charge of records.
First and second leadsman	Take soundings by means of wire reel and hand lead.
Log-reader	Reader of patent log and in charge of log-line when stopping or backing.
Fireman	Engineer of launch.
Coal-heaver	Fireman of launch.

The reel and wire.—The reel consisted of an iron drum 1 fathom in circumference, mounted on the port rail just abaft the engine and capable of being rigged out so that the sounding lead might clear the side. To the end of the stray line, spliced to the wire, a 14-pound lead was attached. On the shaft of the reel, and forward of it, was a grooved wheel, and in the same thwartship plane a similar one on the engine shaft. These were connected by a 1½-inch rope belt, spliced with enough play to allow the engine to run without moving the reel. By means of a small tail block the under part of the belt could be lifted, thus tightening the belt and transmitting the motion of the shaft to the reel. In this way the reeling in was done at any desired speed up to the maximum while going ahead to the next position. To prevent the kinking of the wire the lead should be lifted from the bottom as soon as it strikes, and the strain due to the weight of the lead should be always kept on the part unreeled. To splice on stray line, open the end of the line and stick the wire in a few inches; then bring it outside and wrap it around the stray line several times; then stick it through again and take a few turns around the stray line in the opposite direction and stick the end inside; and, finally, sieze over the end of the wire and the end of the stray line. The wire was kept well oiled, and, when secured, was covered with a blanket band saturated with oil. The entire reel was also covered when secured with a tarpaulin hood. In reeling in, one man laid the wire on the reel, using a piece of canvas to protect his hand.

The taffrail log.—This was fitted to the quarter of the launch and was used in finding the distances apart of soundings taken between positions determined by angles to objects on shore. Distances run by log, like compass courses, are, in the main, only relatively valuable. When running at the ordinary speed of about 5 knots, in smooth water, the distances run by log were found to agree very well with those between plotted positions; but with a head sea, and when running along the beach where there were always currents, its readings are not to be

relied upon. In moderate depths with very rocky bottom it is necessary, when the boat is stopped, that the log reader should gather in the line and rotator, to avoid fouling the screw and catching on rocks. A spare rotator should always be carried.

SECTION V.

INSTRUMENTS AND ARTICLES NEEDED.

For boat work there should be supplied sextants in boxes; a three-arm protractor; binocular glasses; a clock; a compass; dividers and a scale ruler; a box containing pencils, thumb tacks, and erasers; tracing paper or tracing linen for plotting positions near signals; leads and lines; a reel and wire; a taffrail log; two tweezers, a file, and twine for splicing on stray line, and the boat sheet.

Sextant.—Besides the ordinary care in the use of the sextant, particular attention is required to prevent salt water from ruining the silvered glasses. The general practice was to use neither eyepiece nor telescope, since the safety of the instrument required it to be placed in the box before plotting, and the motion of the boat made it necessary to take the angles quickly.

Protractor.—On account of the motion of the boat and the glare arising from the reflection of the light, careful plotting requires too much time. The chief requirement is a quick and moderately accurate determination of the position. Hence, a protractor for use in boat work should be strongly made and should have well-marked graduations and a rather coarse subdivision of verniers. Moreover, the reach of the protractor should be as great as rigidity of construction and convenience will admit. It should not be forgotten that the principal use of the boat sheet is in the guidance of the officer of the boat, and not so much in forming a record of work.

Clock.—The clock was compared with the ship's timepieces before leaving the ship and upon returning on board, and, when the ship was in sight, time signals were made at 8 a. m., noon, and 4 p. m. Although it was not the custom of this survey to use time intervals as a means of plotting soundings, they are frequently so plotted by attempting to maintain an invariable speed in moving between the positions fixed by angles, and observing the time at each cast of the lead. The intervals of space are then regarded as proportional to the corresponding intervals of time.

Compass.—The navy liquid compass, of the size furnished to ship's binnacles, is well adapted to the purposes of hydrographic work in launches. The ordinary boat compass has not sufficient directive force and is too small to steer a sufficiently close course. Owing to the tossing of the launch in a sea way it is difficult to avoid jostling the compass, and, as permanence of position and rigidity of mounting are of the highest importance, some better means should be adopted than is

afforded by the service Y mounted on a spindle and secured by a set screw. It would be an improvement to make the present cylindrical spindles square in section. In order that the compass courses given in the record may be available for plotting positions by course and distance, deviation tables should be formed, and the magnetic courses should be entered in the column headed "Compass courses." The first course on beginning a line of soundings is somewhat experimental and must be corrected by the plotted positions as the work proceeds. The record of preceding work forms a guide, since the lines are generally parallel.

Lead lines and leads.—Three lead lines with 7 and 9 pound leads were used in sounding depths less than 10 fathoms. They were from 15 to 20 fathoms in length, and were marked in the usual manner with additional marks at each fathom of length. For harbor work, and especially in sounding over bars, lines marked in feet are best adapted. The practice was observed of frequently comparing the lines with the reference marks in the deck of the ship and correcting them and the soundings accordingly.

SECTION VI.

RUNNING A LINE OF SOUNDINGS IN A BOAT.

The plan for the development of the hydrography having been furnished to the boat officer in the form of a boat sheet, it becomes his object to conduct the boat over the lines there laid down. This can best be done by keeping the boat in range with natural or artificial objects on shore. To find whether such objects are available for use in any given case plot the position of the boat on the boat sheet by the three-point problem and measure with the protractor the angle formed at the plotted position between the direction of the line which it is proposed to run and a selected shore signal on the right-hand side of the line, set the supplement of the angle thus measured in a sextant, and observe what point on shore the image of the selected shore signal covers. This will be one point of the range, and by noticing what object is in line with this and the boat the required range will be found. When ranges are not available the boat is kept on the line as nearly as possible by fixing its position, by the three-point problem, at intervals of half a mile along the line and changing the course accordingly. In those cases in which it is found impossible to observe angles between signals to fix the position of the boat in commencing a line of soundings close inshore, it was customary to steer as near the line to be run as possible until the first position was obtained, and then fix the inshore end of the line by laying the compass course back from that position. And likewise in coming toward the beach, if the signals were lost to view before the end of the line was reached, it was customary to continue, if possible, the last compass course.

SECTION VII.

FIXING THE POSITION.

The positions of soundings taken in running on a range line are determined by observing and plotting the angles between the direction of the range and a signal on shore to the right or left of it, but when there is no range they are usually determined by observing with sextants in the boat two angles between three fixed objects, called respectively the right, center, and left object. The proper selection of these objects involves a knowledge of the principles of the three-point problem, according to which the position of the sounding will be indeterminate when the circumference passing through the three objects passes also through the position of the boat when the sounding is taken. Indeterminate positions of this class are called "revolvers." When there is reason to suspect such a condition the observer should take a third angle between a fourth object and one of the three already referred to or observe the bearing of a known point. It should be the endeavor of the observer to select signals to carry as long as possible, and especially such as will enable him to establish the course before it is necessary to change to others. In order to secure the most favorable conditions in plotting, the angles should not be less than 30°, and the boat and center object should be on the same side of the line joining the extreme objects. Angles should not be too large to set in the protractor, and the sum of the two angles taken to fix any position should not be greater than the total spread of the arms of the protractor. When there are two observers in a boat they should confer with each other to avoid the latter condition. When the signals were not in the same horizontal plane it was customary to estimate a perpendicular from the higher object and measure the horizontal angle between it and the lower object.

Specimen page of launch's record of soundings.

[Place: San Roque Bay. Observers: Ensigns C. M. Knepper and W. S. Burke. Date: December 6, 1889. Vessel: *Ranger*, third rate. Leadsmen: T. Hammond and A. Mastores. Daymark: G.]

Time.	Reading of patent log.	Distance interval.	No. of position.	Soundings.			Bottom.	Compass course.	Angles.				Remarks.
				Original.	Reduction for tide.	Reduced.			By whom.		Right object.	Left object.	
				Fath.		*Fath.*				° ′			
7.19	29.5	.5	7	53½	.....	52½	s. and bk. sh....	SW. ¾ S	.....	29 04	Asuncion	Ink	
										56 44	Ink	Pablo	
										75 48	Asuncion	Harris	
7.25	29.9	.4	8	55	.....	54	bk sh.....	NW. ½ N.....	.....	26 51	Asuncion	Ink	Ended line. Asuncion bearing NE. ¾ N., distant 4.2 miles.
										56 38	Ink	Pablo	
										73 57	Asuncion	Harris	
7.38	30.9	1.0	9	48¾	.....	47½	s. and brk. sh...	NE. by E.....	.....	35 34	Asuncion	Lead.....	Began line. Asuncion bearing NE. ½ E., distant 4.5 m. Moderate sea from ENE.
										60 18	Lead	Point	
										86 23	Asuncion	Harris	
7.46	31.4	.5	10	43	.....	41¾	rky	NE. ½ E.....	.....	33 45	Asuncion	Ink	
										65 13	Ink	Point	
										88 52	Asuncion	Harris	
7.54	31.9	.5	11	48¾	.....	47½	s. and bk. sh....	NE. ½ N.....	.....	36 53	Asuncion	Ink	
										64 20	Ink	Pablo	Clock 1 minute slow at 8.
										91 00	Asuncion	Harris	
8.04	32.4	.5	12	47¾	8.3	46½	s. and brk. sh...	NE. by N.....	.....	42 30	Asuncion	Ink	Jamb and Peak, patent log reading 32.7—.
										63 35	Ink	Pablo	
										52 42	Ink	Harris	
8.12	32.9	.5	13	47½	.....	46	s. and brk. sh...	N. NE. ½ E....	.....	49 29	Asuncion	Ink	
										62 16	Ink	Pablo	
										51 10	Ink	Harris	

ARRANGEMENT OF THE POOP DECK OF THE U. S. S. RANGER WHILE ENGAGED IN OFFSHORE HYDROGRAPHIC WORK.

SECTION VIII.

SHIP'S WORK.

For the guidance of those engaged in the ship's hydrographic work, deck-board sheets, similar to the boat sheets described in Section II, were constructed on a scale of one-half inch to the nautical mile. They included the same elements as the boat sheets, but embraced a larger extent of territory and showed all the main triangulation stations belonging to the sections which they covered. The work was laid out upon them by drawing a system of lines, one mile apart, perpendicular to the general trend of the coast and crossing them at right angles by a similar system. It then became the object to place a sounding as near as possible to each intersection. In depths less than 30 fathoms the "dipsey" lead was used, but beyond that depth the deep-sea sounding machine.

In fixing the position of a sounding, each of three observers stationed on deck measured with his sextant the angle between a pair of selected objects, which were generally points of the main triangulation. The position was immediately plotted on the deck-board sheet and the course of the ship laid accordingly for the next intersection. At various positions of the ship at different distances from the shore each of these observers also measured the angular altitudes above the shore line or the sea horizon of the peaks used by him in fixing the positions of soundings.

Specimen page of ship's record of soundings.

[Place: Off Morro Hermoso. Observers: Lieut. Commander Reiter, Lieuts. Harris, Bartlett, Lowry, and Halsey. Recorder: H. W. Reed. Date: November 25, 1889. Vessel: U. S. S. *Ranger*. Leadsman: Lieut. C. F. Pond, using wire. Daymark: F.]

Time.	Reading of patent log.	Distance interval.	No. of positions.	Soundings.			Bottom.	Compass, magnetic course.	Angles.				Remarks.
				Original.	Reduction for tide.	Reduced.			By whom.		Right object.	Left object.	
				Fath.		*Fath.*				° ′			
10.13	60.8	0.5	19	38	.....	.....	fne s. brk. sh....	SW. ¾ S.....	O. W. L.	37 55	Peak	High	
									C. W. B.	60 04	High	Noble.....	
									Capt....	54 14	Summit.....	Noble.....	Clear and pleasant; moderate breeze, north wind; long swell, north wind; line begins 10.45 miles SW. by S. from High.
									W. Y. K.	43 44	Peak	Summit.....	
										° ′ ″	*Altitude.*		
									W. R. H.	1 34 00	Low	.....	
									W. R. H.	1 21 55	Lower	.....	
										° ′			
10.22	61.55	0.75	20	39	.....	.....	fne s. brk. sh....	SW. ¾ S.....	O. W. L.	36 37	Peak.....	High	
									C. W. B.	56 26	High	Noble.....	
									Capt....	50 58	Summit.....	Noble.....	
									W. S. H.	42 05	Peak.....	Summit.....	
										° ′ ″	*Altitude.*		
									W. R. H.	1 18 50	Peak.....	.....	
									W. R. H.	1 26 50	Fine.....	.....	
										° ′			
11.02	66.35	4.8	21	54	.....	.....	fne s. brk. sh....	SSW. ⅛ W.....	O. W. L.	29 42	Peak.....	High	
									C. W. B.	39 40	High	Noble.....	
									Capt....	35 39	Summit.....	Noble.....	
									W. Y. H.	33 46	Peak.....	Summit.....	
										° ′ ″	*Altitude.*		
									W. R. H.	1 02 50	Peak	.....	
									W. R. H.	1 06 10	Round	.....	
									W. R. H.	1 04 35	Fine.....	.....	

TOWING THE STEAM LAUNCHES TO A PLACE 25 MILES OFF SAN HIPPOLITO POINT, WHERE A SEARCH FOR SUSPECTED FOUL GROUND WAS TO BE MADE.

To obviate the necessity for allowing for leeway due to the prevailing winds and currents, as well as to avoid confusion arising from having the ship's spars and rigging in the field of view of the observers, the ship was run over that system of lines on the deck-board sheet which lay parallel to the general trend of the coast.

At all times when the ship was at anchor the direction of the surface current was determined and its strength measured by the chip.

The Thomson deep-sea sounding reel was placed at the extremity of the bridge, overhanging the ship's side. It was connected to a double engine, the motive power for reeling in, by an endless belt passing over a grooved wheel, which was thrown into and out of gear by a clutch at the engine. A friction band controlled and stopped the descent of the lead. From an outrigger a leading block was suspended by means of a spring, which was extended with the strain of the lead and line in the water. The instant the strain was relieved the compressive action of the spring tautened a line leading to the break, which, being thus automatically thrown into action, stopped the reel immediately. This machine was severely tried in depths up to 600 fathoms, and was found to be very satisfactory. The wire was reeled in while the ship was going ahead to the next position, the speed of the reeling being regulated by the amount of wire out. At great depths some wire was reeled in before the ship was started. To avoid mistakes in passing the word, the soundings and characters of the bottom were written upon a blackboard for the information of the recorder. The weight of the lead, which was hauled back after every cast, was 40 pounds. Sands' cup was used for securing specimens of the bottom.

Upon one occasion, when an irregular, rocky bottom was found, in order to be certain that a dangerous pinnacle of rock did not escape detection the following method, arranged by Lieut. Commander Reiter, was employed in searching the locality. A series of buoys was made to float anchors or grapnels hanging to 30 fathoms of line. These suspended weights were connected by whale line, preserving equal distances of about 1,000 fathoms between the successive buoys. The ship was taken to windward of the area to be searched, and the buoys and lines were paid overboard. Each end of the line was then taken by a steam launch and it was hauled taut across the direction of the wind. The whole was then allowed to drift slowly with the wind and current, the steam launches preserving the direction of the alignment and controlling the drift. The ship was finally dropped to leeward of the position of the suspected danger and received the drag, which had shown no indication of the existence of any depth less than 30 fathoms. This operation occupied about four hours.

Continuous photographic views of the whole coast were taken from the ship at selected stations near the shore. The time and station occupied were recorded as each photograph was taken and the bearings and distances were afterwards deduced. From these much assistance

was derived in drawing the contour lines of the hills and mountains. Photographs were also taken at the observation spot, at the tidal and magnetic stations, and at many of the principal triangulation stations.

SECTION IX.

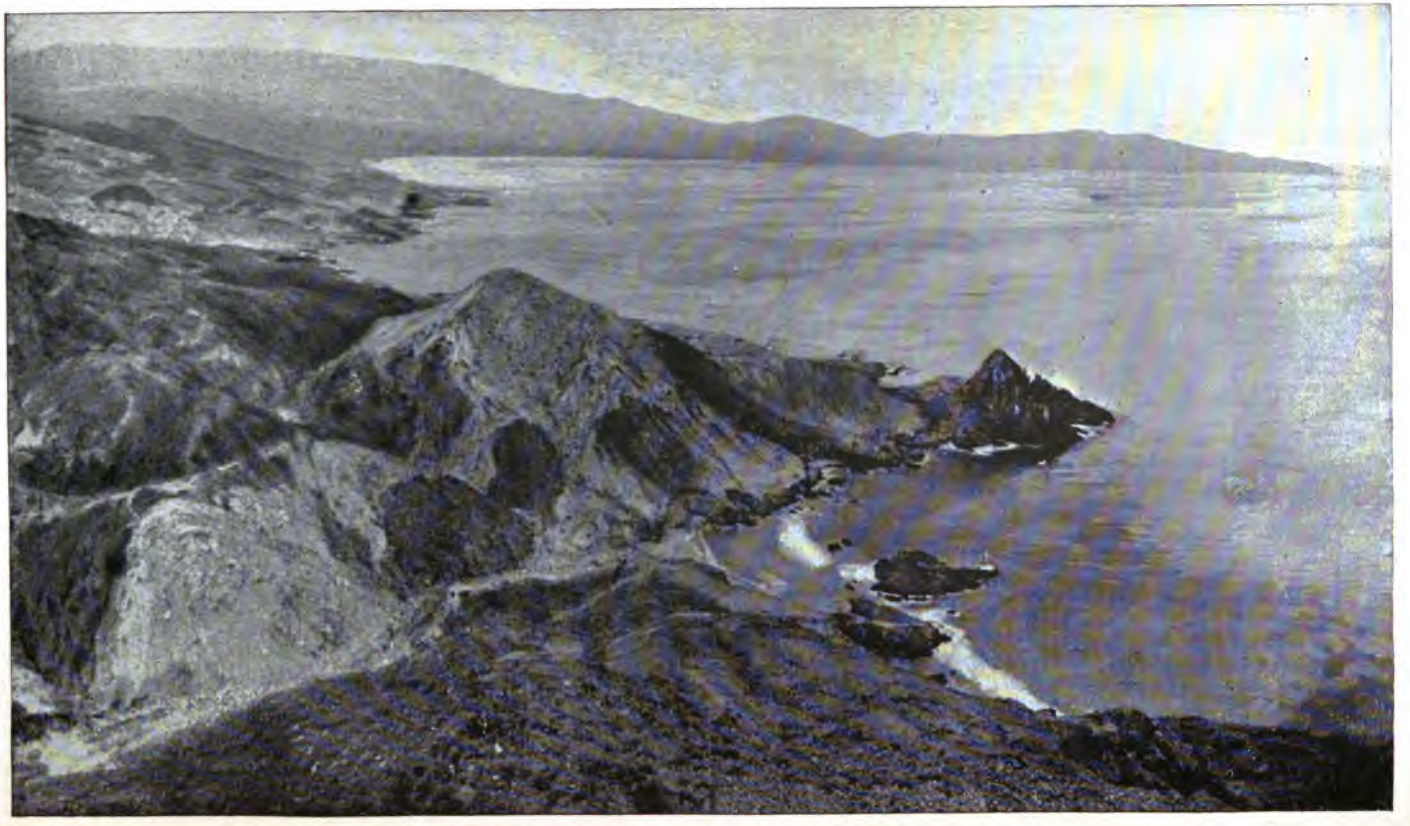
Remarks by Ensign L. S. Van Duzer, U. S. Navy, upon some of the subjects referred to in the foregoing chapter.

Sextants.—For hydrographic work a sextant should be light and compact. The least count of the vernier need not be less than 30 seconds. One that is used in boat work will in a short time undergo a rough usage that will render the attempt to take an angle nearer than 30 seconds under any conditions abortive. To use a sextant as an instrument of precision is not proper in any case, as the chances of error with it are too numerous. The sextant should be capable of measuring an angle of 150° or upwards. All screws should be of good size, with deep, strong threads. The heads of the screws should be large, as they are then less liable to give way under the wrench or screw-driver. The cut for the latter in the screw head should not be too small. The clasps and supports of the horizon and index glasses should be strong and so arranged as to readily admit of all adjustments. The field of the eyepiece should be large and as powerful as possible. The vernier should set close to the limb.

The small sextants used by the Coast Survey (chiefly made in France) are excellent for ordinary work. The graduation of the limb is occasionally defective, however.

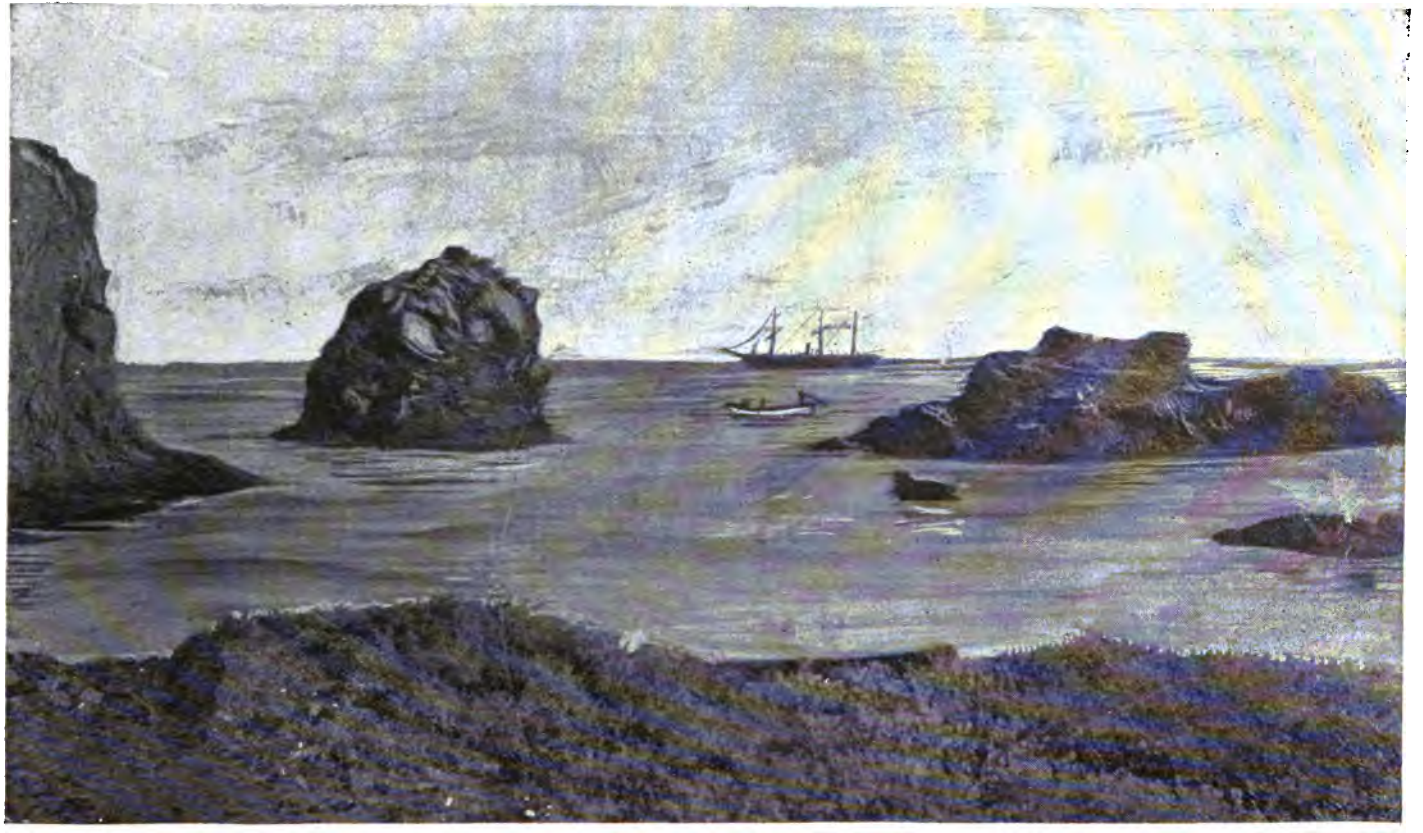
The Townsend double deflecting circle (Van Duzer design for use in boat work) has many advantages. The circular form of the limb is an additional guarantee against distortion. The angles which can be measured are 160° and 165° on the limbs. Both angles may be taken simultaneously by one person if required. A running survey may be prosecuted by two observers. The instrument weighs about half as much as an ordinary sextant. The traversing screws move much faster, enabling the observer to follow the object in a rapidly changing angle without unclamping, an important point when the boat has much motion. The capability of measuring angles in either direction, without inverting the instrument, is very important when the objects, or some of them, are dimly seen. Lastly, the instrument is made of aluminium—sea water and ordinary acids have no effect on it, and it is exceedingly light.

To adjust a sextant.—Adjust the index glass perpendicular to the plane of the limb. To do this place the eye near the index glass in such a position that the reflected image of the limb in that glass may be seen in prolongation of the limb itself. Now move the index arm backward and forward. If in all positions the reflected image and the limb itself appear to join each other without a break and form a sym-



PART OF THE COAST OF CERROS ISLAND, PHOTOGRAPHED TO AID IN THE DEVELOPMENT OF THE TOPOGRAPHY.

PART OF THE COAST OF CERROS ISLAND, PHOTOGRAPHED TO AID IN THE DEVELOPMENT OF THE TOPOGRAPHY.



PART OF THE COAST OF CERROS ISLAND, PHOTOGRAPHED TO AID IN THE DEVELOPMENT OF THE TOPOGRAPHY.

metrical curve the index glass is perpendicular to the plane of the instrument. If not, raise or lower the set screw in rear of the index glass.

To bring the horizon glass perpendicular to the plane of the instrument select a distant rectilinear object with a well-defined edge. The horizon is frequently the best for the purpose. Bring the reflected image and observed image into coincidence. Oscillate the sextant about the line of sight as an axis. If the two images do not separate the glass is in adjustment. If not, raise or lower the screw in rear of the horison glass until the proper adjustment is secured.

To reduce the index error to zero after the instrument is otherwise in adjustment place the zero of the vernier on the zero of the limb, turn the horizon glass about its axis, which is perpendicular to the plane of the instrument, until the reflected image and observed image (or object) coincide. The horizon glass should then be examined to see if it has been thrown out of perpendicular by the last adjustment, and if so, corrected as before.

To take a horizontal angle, bring the plane of the instrument horizontal, with the handle down and in the right hand. Turn the eye (looking through the telescope and unsilvered part of horizon glass) upon the left-hand object. Then unclamp the arm and push it along the limb until the right-hand object appears in the mirror of the horizon glass. Clamp the arm, perfect the contact with the tangent screw, and read. Only practice can enable a person to take horizontal angles under difficulties such as indistinctness of objects and rolling of the boat. When the reflected object is not readily distinguishable as it passes into the field of view, select some prominent point of the horizon as near to it as possible for a *finder*. When the *finder* is reflected, you know the object sought must be near it, and in what direction.

To spare the eyes.—When the seeing is bad do not run the boat as rapidly as usual. Take angles at greater intervals of time (unless the bottom is uneven). At a reduced speed these greater intervals of time will correspond to only the usual distances. Keep the mirrors and glasses of the instrument clear and bright. Always have on hand in the sextant box spare index and horizon mirrors. Do not keep looking through the instrument unnecessarily. Lastly, practice using the left eye.

Care of the sextant.—Keep the limb free from dirt; occasionally wipe it off with a soft, clean rag dipped in weak ammonia. Never polish it with paper or a rag; that scratches it. Never oil the screws holding the index or horizontal glasses in adjustment. Likewise do not show your laziness by pouring sea water over them when the instrument is in adjustment in the hope that the screw threads will become coated with verdigris and so obviate the necessity of daily adjustment. This practice can not be too severely condemned. It has ruined more instruments than any other form of misuse. Notwithstanding the greatest care in handling, instruments will get out of adjustment—new glasses

have to be inserted, and in the attempt to loosen the screws which have become set by the verdigris their heads are ruined by the screw-driver or key, and thenceforth the adjustment of the instrument is a matter of great difficulty, or is impossible without repairs.

Clean the threads of the tangent screw with ammonia and dry them. If working too stiff add a drop of oil or touch of vaseline. See that the screw is not bent, and that the vernier sets down closely to the limb but does not scratch it. Examine the adjustment of the sextant at least twice a day, before beginning and after the close of work, and oftener if there is reason to suspect a change has occurred. It is convenient to keep the index correction reduced to zero, especially for the one who is plotting the office work.

Protractor.—To ascertain if it is in adjustment, examine each arm separately with a steel straightedge and see if the edges are true. Place the right and center arm together. Sometimes this will show a bowing out or in not perceptible by the straightedge. Put on the extension arms and examine with a straightedge as before. If the arms are curved they must be straightened, or else any attempt at adjustment is absurd. If the arms appear to be straight, proceed to the adjustment of the verniers, as follows:

Have a large sheet of paper smoothly stretched on the drawing board. With a straightedge and sharp pencil draw carefully a fine line 4 or 5 feet long. By means of the beam compass construct a perpendicular to the first line at its center. Lay the instrument upon this figure, the center arm on one line, the other on the line at right angles. If the vernier of each movable arm does not show the angle to be 90°, as it should, it must be reset and made to do so.

Angles.—The limit of size of angles can not be laid down for every case. Never use angles less than 30° where avoidable, especially avoid having *both* angles small. When the angles are small (say less than 15°, and such angles *must* be used *if there are no better to be had*) it is preferable to compute the position instead of attempting to plot it with the protractor. The greater length of arm required to reach the various points angled upon the greater the probable error in plotting if the angles are small, as protractors are less and less to be strictly depended upon as the length of arm is increased, and a slight error in a small angle is more important than in a large one.

Handling and care of protractor.—Never use extension arms without putting in the screw clamps. Never lift the protractor from the board or table to set. Lean over it. Protractors are frequently sprung or put out of adjustment by this sort of handling. Besides the limbs are apt to slip of their own weight after setting, or to be knocked out while being returned to the table. To plot quickly you must adopt a system of placing the instrument. Ninety per cent of people place it down in any sort of way and then proceed to twist it around this way and that until a lucky chance causes the three arms to fall on the proper points. While there are a few conditions which may be plotted in other ways, it

will be found *preferable* in *nearly every* case to place the instrument with the central arm on the central object, and the right and left arms each about equally distant from the corresponding object. Keeping the central object on, push the instrument up, reducing the distance of each side arm from its object, but keeping these distances equal as before until all three arms are on the proper objects. A little practice will render this method a very rapid one. It is devoid of all trial or experiment. There is no twisting, turning, or wriggling backward and forward. After the first placing of the instrument on the paper it is simply pushed straight forward into position.

Leads.—The weights of hand leads must be proportioned to the work. Six pounds is sufficiently light for shoal water and light work. With deeper water, strong tides, and steam sounding boats, the heaviest lead that the leadsman can swing, without too great fatigue, is to be preferred.

Lead lines should be marked as follows:

At 1 foot, a small piece of white rag worked into the lay of the rope.
At 2 feet, the same.
At 3 feet, a small piece of leather with the end just visibly protruding from the lay of the rope.
At 4 feet, same as at 1 and 2.
At 5 feet, same as at 1 and 2.
At 1 fathom, a small strip of leather hanging out from the rope about 1 inch.
At 7, 8, 10, 11, and 13, 14, 16, 17 feet, same as 1, 2, 4, and 5.
At 9, 15, 21, 27, 33, 39 feet, etc., same as 3 feet.
At 2 fathoms, two strips of leather similar to the one at 1 fathom.
At 3 fathoms, three strips of leather.
At 4 fathoms, four strips of leather, or a piece of leather with four tails, *i. e.*, slit into four parts, but the slits not reaching quite close up to the line.
At 5 fathoms, white rag.
At 6 fathoms, one strip leather.
At 7 fathoms, red rag.
At 8 fathoms, three strips leather.
At 9 fathoms, four strips leather, or as at 4 fathoms.
At 10 fathoms, piece of leather with a hole in it.
At 11 fathoms, same as at 1.
At 12 fathoms, same as at 2.
At 13 fathoms, same as at 3, or else a blue rag.
At 14 fathoms, same as at 4.
At 15 fathoms, same as at 5, and so forth.

In singing out the sounding the usual "song" should be discarded, especially in rapid sounding. The form of report that the leadsman should make of his sounding is:

"Two fathoms" (12 feet).
"Three—one" (19 feet).
"One—one and a half" (7½ feet).
"Five feet" (5 feet).
"One fathom" (6 feet).
"One fathom and half a foot" (6½ feet).
"One—one" (7 feet), and so forth.

The deck of the vessel and the rail of the sounding boat should both be marked for the purpose of checking the lead line. All lead lines in

use should be constantly soaked. When new ones are bent they should be measured carefully in the morning, at noon, if possible, and at night. All lead lines, new or old, should be measured at least once a day when in use. New lead lines should be well stretched when wet, but not overstretched. The first tendency of a new line when wetted is to contract—much of the shortening will eventually come out in ordinary use, but by stretching it may be nearly all drawn out at once. Always mark lines when wet and after stretching.

Spare leads should be kept in the sounding boat at all times. Do not increase the weight of lead on a line unnecessarily. All leads should have lines attached. A change from a 7 to a 10 pound lead will frequently stretch a small line unduly, with a consequent error in the soundings. Besides, a heavy lead on a small line will cut the leadsman's hands.

The recorder of each boat should be supplied with a small clock with a large second hand, a whistle (preferably of bone or ivory—metal is apt to make the lips sore), a number of pencils (rather hard—records made in soft pencil smear readily), rubber, penknife, the working sounding book and one spare one, and an angle book. He should be informed of the rapidity of sounding in different depths, thus in less than 10 fathoms, say every ten seconds (with two leadsmen, every twenty seconds with one); over 10 fathoms and less than 20, every fifteen seconds; 20 to 30 fathoms, every half minute. It is not possible to get reliable soundings with a hand lead in over 30 fathoms under average conditions. At each ten (fifteen or twenty) seconds the recorder will indicate to the leadsman to sound by means of his whistle. They will get casts alternately. Angles for fixing position should be taken about every three or four minutes (with launch running at 4 miles per hour) if the bottom is not very irregular. Any unusual depth should be located as nearly as possible by angles taken as quickly as can be done after the sounding is obtained. The recorder should give the observers warning of the time to take the next angle by saying, "One minute" or "sounding after the next," according to the instruction of the boat officer, who will regulate the warning interval by the greater or less difficulty in picking up the objects. Whenever there is a change of objects the boat officer or other observer should examine the record to see if the recorder has understood the change and has recorded the names of the new objects correctly.

Ranges.—Ranges are of great value, especially with pulling boats, which are easily thrown off the line by currents, owing to their slow speed. They are useful to steam launches only when the length of line exceeds 2 miles. If it is shorter than this there is more time wasted in getting on the range than the range is worth, provided you have an experienced cockswain who can steer a boat properly. Ranges are almost a necessity in strong and irregular currents if there is to be any attempt at running a system of sounding lines. Ranges should also be used whenever developing bars, channels, and similar work,

in which the greatest precision is desirable. Steering on ranges can only be acquired by long practice. It requires a good eye and some judgment. To get on the range (without erecting range stakes on shore) take a series of positions until you are located somewhere on the range near the inner (or outer) end of the line. Having located the boat on the line (to be sounded), with the protractor ascertain the angle (at this position) between the line and some one of your signals which is most convenient. Set this angle on the sextant. Wherever the reflected image falls on the shore is the outer end of the range. Select some point back for inner end. It is often impossible to get a range when close inshore, so that it is frequently desirable to pick up the range offshore and run in on it to begin the line, shifting to a short range for temporary use when close in and the regular range is obscure. In beginning lines offshore (say at 10 miles) the shore line may not be visible at all. In that case the boat must be steered by compass until the range can be determined. As soon as there is a possibility of picking up a range (with an experienced cockswain this is almost as soon as the shore comes in sight) select the signal nearest the inner end of the range (for that angle will change most slowly) and find the angle between it and the line as before. The approximate range can thus be picked up without stopping the boat and corrected as it grows more distinct.

Steering.—Every boat should be supplied with a large compass graduated to degrees. This compass should be secured in a place which is convenient for the cockswain. Where there are currents nothing but experience will determine the course necessary to be steered. But this course should always be recorded on the boat sheet upon the line so steered. While it is desirable that changes of course should only take place when angles are taken, this is not important unless the bottom is irregular or the change of course considerable. Changes of 3 or 4 degrees may be made at any time if the intervals between angles does not exceed four minutes. Of course the change must be recorded in the sounding book abreast of the proper sounding. When changes of course of over 5 degrees are made angles should be taken at the same time. In strong and irregular currents uniform and evenly spaced lines must not be expected. Reliability and as near approach to uniformity as possible are what should be sought. Cockswains of boats should be taught to steer to degrees and be able to effect a change of course (not the boat's heading) of the boat by 1 degree in fairly smooth water.

In changing the boat's heading it must not be expected that the course made good will change by a similar amount. A change of 45 degrees in the heading may not produce a difference of 10 in the resulting course, while an additional change of 10 degrees may cause a change of 30 or even more in the direction made good, because the added 10 degrees may have brought the current on the other bow or other quarter.

Soundings (*frequency*).—The frequency of sounding depends upon the

character of the bottom, the depth of water, the speed of the boat, and the relative importance of the work. Upon a harbor bar, in a channel, or fairway, where the depths are not ample for all classes of vessels, and where the available width of channel is not great, the number of soundings should be as numerous as possible. In developing a shoal or examining a suspicious locality for dangers to navigation or where considerable irregularities exist the soundings should likewise be closely spaced.

Selection of signals.—In selecting signals always choose those which will give the best determination, giving due weight to well conditioned angles, certainty of location of signals, whether well defined or difficult to see, etc. Triangulation points are always to be preferred over those "cut in" (prosecution) with a sextant.

But, other things being about equal, it is best to choose such objects as can be carried a long time without change. Every shift to new objects introduces a chance for error, and should only be made when plainly desirable. Do not change signals until the course of the boat is established. The distortion and errors of the boat sheet almost always give slight discrepancies in position by the use of different objects, and they may give you trouble in determining the direction to be steered unless you adhere to one set of angles. Of course this is not always practicable, but if using the Van Duzer pattern of the Townshend circle instead of a sextant it is possible always (if there are signals in view) to take a check angle in such cases as this in addition to the regular ones. This is often of great importance, as the check angle will inform you at once whether to depend upon your new position or not.

Very near and very distant signals should be avoided. The first because they are troublesome to plot and the latter because a small error in angle introduces a large one in the resulting position. But in choosing between the two always prefer the near one. In selecting objects be careful of "revolvers" (*i. e.*, indeterminate positions). If the central object is the nearest you are always safe. As a rule the error introduced by signals not being in a horizontal plane is not important. But on large scales and with near objects it may be considerable. A plumb line which will give a point underneath the higher object is frequently convenient when endeavoring to locate a range close inshore, but occasionally in harbor work the angle must be reduced to the horizontal by computation.

Positions may sometimes be determined by one angle and a range. But this is not recommended except for a check. Occasionally two ranges will intersect.

When intending to change the interval in sounding, a prolonged whistle with slight variations will be a guide to the leadsman, who is probably already prepared by the increasing or decreasing depth. Slight changes (say from 10 to 15 seconds) need not be anticipated by any signal at all. The leadsman will simply follow the usual whistle to

THE METHODS OF MOUNTING THE MAGNETOMETER AND DIP-CIRCLE.

"sound" by the recorder. With irregular bottom and rapidly changing depths the leadsman will get his soundings as he can without regard to the interval which will be variable.

CHAPTER IV.

THE MAGNETIC WORK.

The magnetic work of the survey was done by Lieut. C. F. Pond, U. S. Navy. He was provided with theodolite magnetometer No. 2, made by Fauth & Co., Washington, D. C., and dip-circle No. 43, made by John Dover, Charlton, Kent, England.

As no tripod was furnished with the magnetometer, a new and excellent mount was devised, consisting of a boiler flue of brass 4 inches in diameter and 4 feet 7 inches in length, into which the tripod head of the instrument fitted. Abreast one of the flanges of the tripod head a small lug was brazed to the outside of the flue to add to the thickness of the metal, and a small set-screw, working through this and the flue against the flange of the tripod head, held it firmly in place. An oval hole was cut through the side of the flue below its head to allow the insertion of the hand to work the screw connecting the tripod head with the base of the instrument. In place of the two wooden deflection bars, which proved troublesome by warping and swelling, one brass deflection bar was obtained with full section where it passed through the instrument, but cut away at either end on its under side for lightness. This brass bar gave perfect satisfaction.

Two small thumb screws secured this bar inside the above-mentioned tube for safety and convenience in transportation, and the whole arrangement left nothing to be desired for convenience and neatness. The tube weighed 35 pounds and set about 2 feet into the ground, giving a perfectly rigid mount for the instrument, besides occupying much less space than a tripod. Both tube and deflection bar were tested for magnetic qualities and found to be perfectly nonmagnetic.

The accompanying illustrations show the method of mounting as described.

Observations were made by the most approved methods. For declination a mark was first selected in or near the horizon, distant at least half a mile, and for convenience in observing through the door of the tent, bearing as near north as possible.

The time azimuth of the mark was obtained with the altazimuth mounted on the magnetometer circle by three sets of six readings of the sun's lower and upper, first and second limbs (for p. m. azimuths), telescope direct and reversed, with the reading of the mark before and after each set.

The sun's azimuth was obtained by the formula:

$$\tan \tfrac{1}{2} A = \frac{\sin (s-\varphi) \sin (s-h)}{\cos s \cos (s-p)}, \text{ in which } s = \tfrac{1}{2} (\varphi + h + p)$$

The reading of horizontal circle applied to the sun's true azimuth gave circle reading of true north.

Applying to this the reading of the mark the true azimuth of mark was obtained.

With the magnetometer the eastern and western magnetic elongations were observed. The horizontal circle was read at the times of a. m. and p. m. observations, and the reading of the mark recorded before a. m. and after p. m. observations, dismounting the magnet box temporarily for this purpose. The difference between the mean of the eastern and western elongations and the axis of the magnet gave a reduction to the axis which, applied to the reading of the horizontal circle, gave the circle-reading of the magnetic north. The reading of the mark applied to true azimuth of the mark gave the reading of true north, the difference between which and the reading of the magnetic north is the magnetic declination.

The horizontal component of the magnetic force was obtained at each station by the methods of deflections and oscillations, the former giving

$$\frac{m}{H} = \tfrac{1}{2} r^3 \sin \mu \left(1 - \frac{P}{r^2}\right)$$

and the latter

$$mH = \frac{\pi^2 K}{T^2},$$

from which m, the moment of the magnet, and H, the horizontal component of the earth's force, are obtained.

The constant P, depending upon the distribution of magnetism in the deflecting and suspended magnets, was determined at each station by observing deflections at two distances r and r_1, 1.0 and 1.5 feet.

Each set gave a value of $\frac{m}{H}$, as follows:

$$\frac{m}{H} = \tfrac{1}{2} r^3 \sin \mu \left(1 - \frac{P}{r^2}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and

$$\frac{m}{H} = \tfrac{1}{2} r_1^3 \sin \mu_1 \left(1 = \frac{P}{r_1^2}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

from which, solving for P:

$$P = \frac{r^3 \sin \mu - r_1^3 \sin \mu_1}{r \sin \mu - r_1 \sin \mu_1}$$

The value of P, thus obtained, satisfies the two equations (1) and (2), giving the same results for $\frac{m}{H}$.

At the conclusion of season's work all the observations were reworked, using the mean value of P for the season, taking for the final value of $\frac{m}{H}$ at each station the mean of the two values derived from the two sets of deflections.

In solving for P and $\frac{m}{H}$, the value of sin μ (sine of the angle of deflec-

THE MAIN TRIANGULATION STATION ON LAGOON HEAD, WITH THE MAGNETIC STATION IN THE FOREGROUND.

THE ARRANGEMENT OF A MAGNETIC CAMP.

tion) in one set was reduced to the temperature of the other set by the formula $\sin \mu_0 = \sin \mu [1-(t_0 - t)q]$, taking as the standard that temperature which more nearly agreed with the temperature at time of observations for oscillations, thus making the reduction for temperature in computing oscillations for m and H as small as possible, care being taken to observe deflections and oscillations at as near the same temperature as possible. In the formula

$$mH = \frac{\pi^2 K}{T^2}$$

T is the corrected time of one oscillation, or

$$T^2 = T_1^2 \left(1 + \frac{h}{f}\right)[1-(t'-t)q]$$

where T_1 is the observed time of one oscillation corrected for rate of chronometer, $1 + \frac{h}{f}$ is the coefficient of torsion obtained in the usual way, t' the temperature at the time of observations for oscillations, and t the temperature at the time of observations for deflections.

The mean value of H obtained at each station, expressed in British (foot, grain, and second) units, was reduced to C. G. S. (centimeter, gram, and second) units by the log factor 8.66378; and total force, expressed in British and C. G. S. units, was computed by the formula $F = H \times$ sec. dip.

The values of m obtained were reduced to a standard temperature, $t = 75°$, by the formula $m_0 = m(1-(t_0 - t)q)$.

The magnetic dip was observed at each station by the ordinary method, care being taken to keep needles, pivots, and bearings free of moisture and dust, and in reversing polarity to shift magnets end for end after half the passes had been made.

At each station occupied a cairn was built and a record buried, in a bottle, so that the spot may be readily recovered by subsequent observers.

The record of the magnetic work done at Asuncion Island, Lower California, is here given in order to show the manner of recording the observations and deducing the results.

DESCRIPTION OF STATION.

The station is situated at the northern end of the island, near the middle of its breadth, in latitude N. 27° 06′ 30″, and longitude W. 114° 17′ 40″. It is 420 feet south of the bottom of a bight in the north shore of the island, 280 feet west of a point of bluff which projects slightly beyond the general line of bluff on the east coast, and 205 feet east of the summit of a well-marked white knoll.

To mark the spot, which is only 38 feet south of the station occupied in 1873 by Assistant Eimbeck, of the U. S. Coast and Geodetic Survey, and in 1881 by Lieut. Commander H. E. Nichols, U. S. Navy, also of the U. S. Coast and Geodetic Survey, a complete record of its occupation, sealed in a bottle, was buried and a cairn of stones 3 feet high was erected over it.

The mark used is a peak on the mainland bearing 10° 30′.2 west (true), distant about 5 miles. It just shows through a notch in the mountains beyond.

Station: Asuncion Island, Lower California.
Date: December 13, 1889; Hour, 1:40–2:10 p. m., 120th Meridian Time.
Instrument: Alt. Az. No. 2; Chro. 8*h*. 01*m*. 47.9 *sec.* slow of G. M. T.
Observer: Lieut. Charles F. Pond. Recorder: H. W. Reed, Eq. Yeo.

Chronometer time.	Horizontal circle. A.	Horizontal circle. B.	Vertical circle. A.	Vertical circle. B.	Remarks.
Set I.	⊙'s lower and first limbs. Telescope *d*.				Reading of mark.
h. m. s.	° ′	° ′	° ′	° ′	
1 39 30.5	259 53	79 54	30 39	210 40.5	Before.
40 59.5	260 13	80 13.5	30 28	210 29	A. 34° 0.5′.
42 07	260 28	80 29	30 19.5	210 21	B. 214° 0.6′.
	⊙'s upper and second limbs. Telescope R.				Chro.
45 20	80 30.5	260 32	149 57	329 55	Eggerts' Sons, 468.
46 31.5	80 47	260 48	150 06	330 04.5	
1 47 38.5	81 01.5	261 02	150 15	330 13.5	
Set II.	⊙'s upper and second limbs. Telescope R.				
1 51 05.5	81 46	261 46.5	150 43	330 41	After.
52 15	82 01	262 01.5	150 52.5	330 51	A. 214° 0.4′.
53 39	82 18.5	262 19	151 03	331 02	B. 34° 0.5′.
	⊙'s lower and first limbs. Telescope D.				Bar. 30.14 in.; ther. 73°.
56 49.5	263 35	83 36.5	28 20	208 22	
58 03.5	263 51	83 52.5	28 10.5	208 12	
1 59 30.5	264 09	84 10	27 59	208 00	
Set III.	⊙'s lower and first limbs. Telescope D.				
2 02 26	264 45	84 46	27 33	207 35	After.
03 34	264 59	85 00	27 24	207 26	A. 34° 05′.
04 39	265 11.5	85 13	27 15	207 16.5	B. 214° 06′.
	⊙'s upper and second limbs. Telescope R.				
06 46.5	85 00	265 01	152 55	332 53.5	After.
08 53.5	85 25.5	265 26	153 13	333 11	A. 214° 04′.
2 10 17.5	85 42	265 42.5	153 25	333 24	B. 34° 05′.

Lat. 27° 06′ 21″ N. Long. 114° 18′ 13″ W.

	Mean chro. time.	Mean hor. circle.	Mean ver. circle.	Cor. for par. and ref.	Corrected altitude.
	h. m. s.	° ′ ″	° ′ ″	′ ″	° ′ ″
Set I.	1 43 41	260 29 18	30 12 10	1 28	30 10 42
Set II.	1 55 14	262 57 12	28 39 15	1 34	28 37 41
Set III.	2 06 06	265 10 58	27 07 20	1 41	27 05 39

COMPUTATION.

Formula,

$$\tan^2 \tfrac{1}{2} A = \frac{\sin (s-\phi) \sin (s-h)}{\cos s \cos (s-p)}, \text{ in which}$$

$$s = \tfrac{1}{2} (\phi + h + p).$$

	Set I.				Set II.				Set III.			
	°	′	″		°	′	″		°	′	″	
ϕ	27	06	21		27	06	21		27	06	21	
h	30	10	42		28	37	41		27	05	39	
p	113	13	13		113	13	14		113	13	16	
$2s$	170	30	16		168	57	16		167	25	16	
s	85	15	08	sec 1.08213	84	28	38	sec 1.01664	83	42	38	sec 0.96036
$s-\phi$	58	08	47	sin 9.92911	57	22	17	sin 9.92540	56	36	17	sin 9.92163
$s-h$	55	04	26	sin 9.91376	55	50	57	sin 9.91780	56	36	59	sin 9.92169
$s-p$	27	58	05	sec 0.05394	28	44	36	sec 0.05711	29	30	38	sec 0.06035
				2)0.97894				2)0.91695				2)0.86403
$\frac{1}{2}$ A	72	02	53	tan 0.48947	70	48	52	tan 0.45848	69	42	18	tan 0.43202
A	144	05	46						139	24	36	

RECAPITULATION.

	Set I.			Set II.			Set III.		
	°	′	″	°	′	″	°	′	″
ϕ	27	06	21	27	06	21	27	06	21
h	30	10	42	28	37	41	27	05	39
p	113	13	13	113	13	14	113	13	16
A (from North)	144	05	46	141	37	44	139	24	36
Circle reads	260	29	18	262	57	12	265	10	58
North meridian reads	44	35	04	44	34	56	44	35	34

	°	′	″	
Mean north meridian	44	35	11	
Mark reads	34	05	00	
Azimuth of mark	10	30	11	W.

MAGNETIC OBSERVATIONS.

DECLINATION.

Date: December 2, 1889.
Station: Asuncion Island, Lower California.
Instrument: Theodolite magnetometer No. 2.
Magnet No. 2 suspended by one fiber, scale erect.
Observer: Lieut. Charles F. Pond, U. S. Navy.
Line of detorsion 120°.

Local time.	Scale-readings.		Mean.	Azimuth circle A 274° 06′ B 94 05.5
a. m.	Left.	Right.		
h. m.	*d.*	*d.*	*d.*	
7 50	22.4	33.6	28.00	Remarks:
8 00	24.2	31.8	28.00	Put in new fiber and suspended torsion weight over night. From 6:18 to 7:30 removing torsion. Read mark and at 7:45 suspended magnet. Weather overcast and cloudy; light E. breeze.
10	25.8	30.2	28.00	
20	26.9	29.1	28.00	
30	27.1	28.9	28.00	
40	27.4	28.6	28.00	
50	27.7	28.3	28.00	
9 00	27.9	28.2	28.05	Observed axis of magnet No. 2 and one set of dips. Suspended torsion weight after 10:15 a. m.
10	28.0	28.1	28.05	
20	28.1	28.1	28.10	
30	28.1	28.1	28.10	
40	28.1	28.1	28.10	
50	28.0	28.1	28.05	
10 00	28.0	28.1	28.05	
p. m.	Line of detorsion 330°.			Azimuth circle A 274° 06′ B 94 06
12 10	22.2	34.1	28.15	
20	24.8	31.6	28.20	Remarks:
30	26.2	29.9	28.05	Moved torsion circle through 150°. At 12:15 moved torsion weight and suspended magnet.
40	27.1	29.1	28.10	
50	27.3	28.9	28.10	
1 00	27.8	28.6	28.20	Weather warm and pleasant; clearing light NW. airs.
10	27.9	28.3	28.10	
20	28.0	28.1	28.05	Observed two sets oscillations and two sets deflections and suspended torison weight for night.
30	28.0	28.1	28.05	
40	28.1	28.1	28.10	
50	28.1	28.1	28.10	
2 00	28.1	28.1	28.10	

COMPUTATION.

Reading of Mark.

At beginning of a. m. observations	A	252	40
	B	72	39
At end of p. m. observations	A	252	39.5
	B	72	39.2
Mean,		252	39.2

Determination of scale-value of magnet.			Determination of axis of magnet.					
Scale.	Circle readings, mean of verniers.	Value of divisions.	Scale.	Scale-readings.		Mean.	Alternate mean.	Axis.
	° ′ ″							*d.*
			E	28.0	28.1	28.05	.....	.....
			I	31.8	23.0	27.40	28.05	27.72
			E	12.2	43.9	28.05	27.40	27.72
			I	38.0	16.8	27.40	28.05	27.72
			E	21.9	34.2	28.05	27.42	27.74
			I	32.1	22.8	27.45	28.02	27.74
			E	20.0	36.0	28.00	.....	.....
Value of one division of scale=6.25′.			Scale-reading of axis.....					27.73
Mean scale-reading of east and west magnetic elongation.....								28.08

	°	′		
Reduction to axis.....	+	2.2	=diff.=+	0.35
Azimuth circle reads.....	274	05.9		
Magnetic N. meridian reads.....	274	08.1		
Mean reading of mark	252	39.2		
Azimuth of mark W. of N.....	10	30.2		
True meridian reads.....	263	09.4		
Magnetic declination	10	58.7	E	

MAGNETIC OBSERVATIONS.

DECLINATION.

Date: December 3, 1889.
Station: Asuncion Island, Lower California.
Instrument: Theodolite magnetometer No. 2.
Magnet No. 2 suspended by one fiber scale erect.
Observer: Lieut. Charles F. Pond, U. S. Navy.
Line of detorsion 240°.

Local time.	Scale-readings.		Mean.	Azimuth circle, A 274° 06.5 B 94 06
a. m.	Left.	Right.		
h. m.	*d.*	*d.*		
7 20	20.0	36.3	28.15	Remarks:
30	22.7	33.7	28.20	6:00 to 7:00 a. m. moving torsion from fiber
40	24.8	31.6	28.20	and readjusting level.
50	26.2	30.0	28.10	Read mark and at 7:10 suspended magnet.
8 30	27.0	29.1	28.05	Weather overcast; light E. and SE. breeze.
10	27.4	28.8	28.10	Observed two sets oscillations and two sets
20	27.8	28.4	28.10	deflections.
8 30	27.9	28.2	28.05	At 11 a. m. suspended torsion weight.
p. m.	Line of detorsion 250°.			Azimuth circle, A 274° 06.5 B 94 06
11 40	24.0	31.7	27.85	Remarks:
11 55	25.9	29.7	27.80	At 11:30 removed torsion weight and sus-
12 10	27.0	28.6	27.80	pended magnet, turning torsion circle
20	27.3	28.1	27.70	through 10°.
30	27.6	28.0	27.80	Weather cloudy and hot; light NW. breeze.
40	27.7	27.9	27.80	Observed one set dips and value of scale di-
50	27.8	27.9	27.85	vision of magnet No. 2.
1 00	27.9	27.9	27.90	

COMPUTATION.

READING OF MARK.

At beginning of a. m. observations,	A	252	40
	B	72	39
At end of p. m. observations,	A	252	39
	B	72	39
Mean,		252	39.4

Determination of scale-value of magnet.			Determination of axis of magnet.					
Scale.	Circle readings, mean of verniers.	Value of divisions.	Scale.	Scale-readings.		Mean.	Alternate mean.	Axis.
	° ′ ″							*d.*
5	276 28 30	.....	E					
15	275 25 30	1 03 00	I					
25	274 23 15	1 02 15	E					
35	273 20 45	1 02 30	I					
45	272 18 45	1 02 00	E					
45	272 18 45	1 02 00	I					
35	273 20 45	1 02 15	E					
25	274 23 00	1 03 00						
15	275 26 00	1 02 15						
5	276 28 45	1 02 45						
Value of one division of scale = 6.25′.			Scale-reading of axis.....					27.73
Mean scale-reading of east and west magnetic elongation.....								27.95
				°	′	= diff. = +		0.22
Reduction to axis.....				+	1.4			
Azimuth circle reads				274	06.2			
Magnetic N. meridian reads.....				274	07.6			
Mean reading of mark.....				252	39.4			
Azimuth of mark W. of N.....				10	30.2			
True meridian reads.....				263	09.6			
Magnetic declination				10	58.0	E		

MAGNETIC OBSERVATIONS.

DECLINATION.

Date: December 4, 1889.
Station: Asuncion Island, Lower California.
Instrument: Theodolite magnetometer No. 2.
Magnet No. 2: suspended by one fiber, scale erect.
Observer: Lieut. Charles F. Pond, U. S. Navy.
Line of detorsion 210°.

Local time. a. m.	Scale-readings. Left.	Right.	Mean.	Azimuth circle, A 274° 10′ B 94° 09.5
h. m.	*d.*	*d.*	*d.*	Remarks:
7 05	17.9	37.2	27.55	5 a. m. to 7 a. m., moved torsion from fiber.
15	22.7	32.5	27.60	Lint O. K. At 7 a. m. moved torsion weight and suspended magnet, first reading mark.
25	24.3	30.8	27.55	Weather cloudy; light SE. breeze; threatening rain.
35	25.8	29.3	27.55	At 7:45 suspended torsion weight.
45	26.5	28.7	27.60	
7 55	27.0	28.1	27.55	
8 05	27.2	28.0	27.60	
15	27.3	27.9	27.60	
25	27.5	27.8	27.65	
35	27.7	27.8	27.75	
45	27.8	27.8	27.80	
8 55	27.7	27.8	27.75	
9 05	27.7	27.8	27.75	
15	27.8	27.8	27.80	
25	26.8	28.7	27.75	
9 35	27.1	28.2	27.65	

p. m.	Line of detorsion 190°.			Azimuth circle, A 274° 10′ B 94° 09.5
11 40	17.7	37.0	27.35	Remarks:
11 55	23.2	31.2	27.20	At 11:10 removed torsion weight and turned torsion circle through 20°; observed axis of magnet No. 4. At 11:35 suspended magnet No. 2.
12 10	25.5	28.9	27.20	Weather cloudy and sultry; light rain.
20	26.2	28.1	27.15	
30	26.7	27.7	27.20	
40	26.9	27.4	27.15	
12 50	27.0	27.3	27.15	
1 00	27.0	27.2	27.10	
10	27.1	27.1	27.10	
20	27.1	27.2	27.15	
30	27.1	27.2	27.15	
40	27.1	27.2	27.15	

COMPUTATION.

Reading of Mark.

		°	′
At beginning of a. m. observations,	A	252	39
	B	72	38.5
At end of p. m. observations,	A	252	39
	B	72	39
Mean,		252	38.9

Determination of scale value of magnet.			Determination of axis of magnet No. 4.					
Scale.	Circle readings, mean of verniers.	Value of divisions.	Scale.	Scale readings.		Mean.	Alternate mean.	Axis.
	° ′ ″							*d*
			E	24.2	35.9	30.05	.....	.....
			I	35.4	19.1	27.25	30.02	28.64
			E	27.0	33.0	30.00	27.22	28.61
			I	34.2	20.2	27.20	30.00	28.60
			E	20.2	39.8	30.00	27.22	28.61
			I	30.5	24.0	27.25	30.00	28.62
			E	29.5	30.5	30.00	.....	.....
								28.61

Value of one division of the scale = 6′.25.	Scale reading of axis			27.73
Mean scale-reading of east and west magnetic elongation				27.45
Reduction to axis	0	1.8	= difference =	0.28
Azimuth circle reads	274	09.8		
Magnetic N. meridian reads	274	08.0		
Mean reading of mark	252	38.9		
Azimuth of mark W. of N	10	30.2		
True meridian reads	263	09.1		
Magnetic declination	10	58.9	E	

MAGNETIC OBSERVATIONS. DIP.

Date: December 2, 1889.
Station: Asuncion Island, Lower California.
Dip circle No. 43: John Dover. Needle No. 2.
Observer: Lieut. Charles F. Pond, U. S. Navy.

[Mean by polarities, 51° 54′.2. Mean by polarities, 51° 52′.4.]

Polarity of marked end south.

Circle east.				Circle west.			
Face east.		Face west.		Face east.		Face west.	
S.	N.	S.	N.	S.	N.	S.	N.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
52 04	51 49	51 51	51 35	52 19	52 22.5	52 08	52 09
04.5	50	50	34	20	23	07.5	08.5
03.5	50	50	34	19.5	22.5	06	07
52 04	51 49.7	51 50.3	51 34.3	52 19.5	52 22.7	52 07.2	52 08.2
51° 50′.8		51° 42′.3		52° 21′.1		52° 07′.7	
51° 49′.6				52° 14′.4			
Mean, 52° 02′							

Polarity of marked end north.

Circle west.				Circle east.			
Face west.		Face east.		Face west.		Face east.	
S.	N.	S.	N.	S.	N.	S.	N.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
52 04.5	52 07	51 51.5	51 53.5	51 42	51 29	51 30	51 15.5
03.5	06	50	52	43	51 30	32.5	18
04	06.5	49.5	51.5	42.5	29.5	33	18.5
52 04	52 06.5	51 50.3	51 52.3	51 42.5	51 29.5	51 31.8	51 17.3
52° 05′.2		51° 51′.3		51° 36′		51° 24′.6	
51° 58′.8				51° 30′.3			
Mean, 51° 44′.6							

Resulting dip, 51° 53′.3.

Local time of beginning, 10:30 a. m.
Local time of ending, 11:10 a. m.
Magnetic meridian reads, 23° 31′

Circle in Mag. prime vertical.

	° ′
Circle N. Needle N.,	23 32
S.,	23 10
Circle S. Needle N.,	23 53
S.,	23 29
Mean	23 31

MAGNETIC OBSERVATIONS. DIP.

Date: December 3, 1889.
Station: Asuncion Island, Lower California.
Dip circle No. 43: John Dover. Needle No. 2.
Observer: Lieut. Charles F. Pond, U. S. Navy.

[Mean by polarities, 57° 52′.1. Mean by polarities, 51° 53′.1.]

Polarity of marked end north.

Circle east.				Circle west.			
Face east.		Face west.		Face east.		Face west.	
S.	N.	S.	N.	S.	N.	S.	N.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
51 33.5	51 20	51 45	51 32	51 49	51 50	52 04.5	52 07.5
33	19.5	43.5	30	49	50	04	07
31	17	43	29.5	50	51	05	08
51 32.5	51 18.8	51 43.8	51 30.5	51 49.3	51 50.3	52 04.5	52 07.5
51° 25′.6		51° 37′.2		51° 49.′8		52° 06′	
51° 31′.4				51° 57′.9			
Mean, 51° 44′.6							

Polarity of marked end south.

Circle west.				Circle east.			
Face west.		Face east.		Face west.		Face east.	
S.	N.	S.	N.	S.	N.	S.	N.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
52 10	52 13	52 13	52 16	51 56	51 40.5	51 57	51 43
09.5	12.5	12	15	55.5	40	56.5	43
10.5	13.5	13	16	54 5	38	55	41
52 10	52 13	52 12.7	52 15.7	51 55.3	51 39.5	51 56.2	51 42.3
52° 11′.5		52° 14′.2		51° 47′.4		51° 49′.2	
52° 12′.8				51° 48′.3			
Mean, 52° 00′.6							

Resulting dip, 51° 52′.6.

Local time of beginning, 1:55 p. m.
Local time of ending, 2:40 p. m.
Megnetic meridian reads, 83° 26′

Circle in Mag. prime vertical.

		° ′
Circle N.	Needle N.,	83 07.5
	S.,	83 14
Circle S.	Needle N.,	83 30
	S.,	83 53
	Mean,	83 26.1

MAGNETIC OBSERVATIONS. DIP.

Date: December 4, 1889.
Station: Asuncion Island, Lower California.
Dip circle No. 43: John Dover. Needle No. 2.
Observer: Ensign W. I. Burke, U. S. Navy.

Polarity of marked end.							
Circle east.				Circle west.			
Face east.		Face west.		Face east.		Face west.	
S.	N.	S.	N.	S.	N.	S.	N.
° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
52 00	51 47	51 58.5	51 43	52 13	52 14	52 11	52 14
00	48	57	42	12	12	11.5	13
52 00	51 47.5	51 57.8	51 42.5	52 12.5	52 13	52 11.2	52 13.5
51° 53′.8		51° 50′.2		52° 12′.8		52° 12′.4	
51° 52′				52° 12′.6			
Mean, 52° 2′.3							

Observations not completed for want of time. Difference between means

Polarity N. S.	′
December 2,	=17.4
December 3,	15.9
Mean difference between means,	16.6
Applying half of this to above means gives,	52° 2′.3
Mean,	8′.3

Resulting dip, 51° 54′.

Local time of beginning,	3:30 p. m.
Local time of ending,	4:05 p. m.
Magnetic meridian reads,	83° 24′

Circle in Mag. prime vertical.

		° ′
Circle N.	Needle N.,	83 1
	S.,	82 56
Circle S.	Needle N.,	83 54
	S.,	83 45
	Mean,	83 24

MAGNETIC OBSERVATIONS. HORIZONTAL INTENSITY.

Deflections with Theodolite Magnetometer.

Date: December 2, 1889.
Station: Asuncion Island, Lower California.
Instrument: Theodolite magnetometer No. 2.
Magnet No. 2, deflecting at right angles to magnet No. 4, suspended.
Observer: Lieut. Charles F. Pond, U. S. Navy.

Distance $r = 1.0$ foot. log. $r = 0.00000$.

Magnet.	North end.	Circle readings. No.	A	B	Mean.	Circle readings. No.	A	B	Mean.
			° ′	′	′		° ′	′	′
East.	E.	1	276 30	30	30			2.5	2.75
	W.					2	273 03		
	E.	3	276 31	30.5	30.75				
	W.					4	273 03	2	2.50
	E.	5	276 31	30.5	30.75				
	Mean,				30.50				2.62
West.	W.					6	273 01.5	1.0	1.25
	E.	7							
	W.					8	273 01.5	1.0	1.25
	E.	9							
	W.					10	273 01.5	1.0	1.25
	Mean,				28.75				1.25

Computation: $\frac{m}{H} = \frac{1}{4} r^3 \sin u \left(1 - \frac{P}{r^2} \cdots\cdots\right)$ $\quad P = +0.00140$

				Logarithms.
	° ′			
Magnet east,	$2u = 3$ 27.88		$\frac{1}{4}$	9.69897
Magnet west,	$2u = 3$ 27.50		r^3	0.00000
Mean,	3 27.69		$\sin u$	8.4800248
	$u = 1$ 43.84		$1 - \frac{P}{r^2}$	9.9903916
Time of beginning,	3:20 p. m.	° Temp., 78		
Time of ending,	3:40 p. m.	Temp., 78		
		$t = 78$		
Mean,	3:30		$\frac{m}{H}$	8.1783864

MAGNETIC OBSERVATIONS. HORIZONTAL INTENSITY.

DEFLECTIONS WITH THEODOLITE MAGNETOMETER.

Date: December 2, 1889.
Station: Asuncion Island, Lower California.
Instrument: Theodolite magnetometer No. 2.
Magnet No. 2, deflecting at right angles to magnet No. 4, suspended.
Observer: Lieut. Charles F. Pond, U. S. Navy.

Distance $r = 1.5$ feet. log. $r = 0.1760913$.

Magnet.	North end.	Circle readings. No.	A	B	Mean.	Circle readings. No.	A	B	Mean.
			° ′	′	′		° ′	′	′
East.	E.	1	275 18	17	17.50				
	W.								
	E.	3	275 18	17	17.50	2	274 16	15	15.50
	W.					4	274 16	15	15.50
	E.	5	275 18	17	17.50				
	Mean,				17.50				15.50
West.	W.					6	274 15.5	14.5	15.00
	E.	7	275 17	16	16.50				
	W.					8	274 15	14	14.50
	E.	9	275 17	16	16.50				
	W.					10	274 15	14	14.50
	Mean,				16.50				14.67

Computation: $\frac{m}{H} = \frac{1}{2} r^3 \sin u \left(1 - \frac{P}{r^2} \ldots\ldots\right)$ $\quad P = +0.00140$

			Logarithms.
	° ′		
Magnet east,	$2u = 1\ 02$		
Magnet west,	$2u = 1\ 01.83$	$\frac{1}{2}$	9.69897
Mean,	$1\ 01.92$	r^3	0.5282739
	$u = 30.96$	$\sin u$	7.9544600
		$1 - \frac{P}{r^2}$	9.9997297
Time of beginning,	3:40 p. m.	° Temp., 78	
Time of ending,	4:00 p m.	Temp., 78	
		77	
Mean.	3:50	$t = 77.7$	
		$\frac{m}{H}$	8.1814366
		Mea $\frac{m}{H}$	$= 8.1799135$

MAGNETIC OBSERVATIONS. HORIZONTAL INTENSITY.

Deflections with Theodolite Magnetometer.

Date: December 3, 1889.
Station: Asuncion Island, Lower California.
Instrument: Theodolite magnetometer No. 2.
Magnet No. 2, deflecting at right angles to magnet No. 4, suspended.
Observer: Lieut. Charles F. Pond, U. S. Navy.

Distance $r = 1.0$ foot. log. $r = 0.000000$.

Magnet.	North end.	Circle readings. No.	A	B	Mean.	Circle readings. No.	A	B	Mean.
			° ′	′	′		° ′	′	′
East.	E.	1	276 32	32	32.00				
	W.					2	273 04	03.5	3.75
	E.	3	276 33	32.5	32.75				
	W.					4	273 03.5	03.0	3.25
	E.	5	276 32	31	31.50				
	Mean,				32.08				3.50
West.	W.					6	273 1.5	01	1.25
	E.	7	276 29	28	28.50				
	W.					8	273 1.5	01	1.25
	E.	9	276 29	28	28.50				
	W.					10	273 2.0	01	1.50
	Mean,				28.50				1.33

Computation: $\frac{m}{H} = \frac{1}{2} r^3 \sin u \left(1 - \frac{P}{r^2} \ldots\ldots\right)$ $P = +0.00140$

			Logarithms.
	° ′		
Magnet east,	$2u = 3$ 28.58		
Magnet west,	$2u = 3$ 27.17	$\frac{1}{2}$	9.69897
Mean,	3 27.88	r^3	0.00000
	$u = 1$ 43.94	$\sin u$	8.4804426
		$1 - \frac{P}{r^2}$	9.9993916
Time of beginning,		Temp.,	
Time of ending,		Temp.,	
Mean,		$t =$	$\frac{m}{H}$ 8.1788042

MAGNETIC OBSERVATIONS. HORIZONTAL INTENSITY.

DEFLECTIONS WITH THEODOLITE MAGNETOMETER.

Date: December 3, 1889.
Station: Asuncion Island, Lower California.
Instrument: Theodolite magnetometer No. 2.
Magnet No. 2, deflecting at right angles to magnet No. 4, suspended.
Observer: Lieut. Charles F. Pond, U. S. Navy.

Distance $r = 1.5$ feet. log. $r = 0.1760913$.

Magnet.	North end.	Circle readings. No.	A	B	Mean.	Circle readings. No.	A	B	Mean.
			° ′	′	′		° ′	′	′
East.	E.	1	275 17	16	16.50				
	W.					2	274 16	15	15.50
	E.	3	275 17.5	16.5	17.00				
	W.					4	274 16	15	15.50
	E.	5	275 17.5	16	16.75				
	Mean,				16.75				15.50
West.	W.					6	274 14	13	13.50
	E.	7	275 16	15	15.50				
	W.					8	274 14	13	13.50
	E.	9	275 16	15	15.50				
	W.					10	274 14	13	13.50
	Mean,				15.50				13.50

Computation: $\frac{m}{H} = \frac{1}{2} r^3 \sin u \left(1 - \frac{P}{r^2} \ldots\ldots\right)$ $P = +0.00140$

		Logarithms.
Magnet east, $2u =$	1 1.25	
Magnet west, $2u =$	1 2	
Mean,	1 1.62	
$u = m$	30.81	
	$\frac{1}{2}$	9.69897
	r^3	0.5282739
	$\sin u$	7.9515948
	$1 - \frac{P}{r^2}$	9.9997297
Time of beginning, Temp.,		
Time of ending, Temp.,		
Mean,	$t = 81°.7$	
	$\frac{m}{H}$	8.1785684
	Mean $\frac{m}{H} = 8.17868$	

MAGNETIC OBSERVATIONS. HORIZONTAL INTENSITY.

Deflections with Theodolite Magnetometer.

Date: December 4, 1889.
Station: Asuncion Island, Lower California.
Instrument: Theodolite magnetometer No. 2.
Magnet No. 2, deflecting at right angles to magnet No. 4, suspended.
Observer: Lieut. Charles F. Pond, U. S. Navy.

Distance $r = 1.0$ foot. log. $r = 0.00000$.

Magnet.	North end.	Circle readings. No.	A	B	Mean.	Circle readings. No.	A	B	Mean.
			° ′	′	′		° ′	′	′
East.	E.	1	276 31	30	30.50				
	W.					2	273 02	2	02.00
	E.	3	276 31	31	31.00				
	W.					4	273 02	1.5	01.75
	E.	5	276 31	30.5	30.75				
	Mean,				30.75				01.88
West.	W.					6	273 00	00.0	00.00
	E.	7	276 29	28	28.50				
	W.					8	273 00	59.5	59.75
	E.	9	276 29	28.5	28.75				
	W.					10	273 00	59.5	59.75
	Mean,				28.62				272° 59′.83

Computation: $\frac{m}{H} = \frac{1}{2} r^3 \sin u \left(1 - \frac{P}{r^2} \ldots\ldots\right)$ $\quad P = +0.00140$

				Logarithms.
	° ′			
Magnet east,	$2u = 3$ 28.87			
Magnet west,	$2u = 3$ 28.79		$\frac{1}{2}$	9.69897
Mean,	3 28.83		r^3	0.00000
	$u = 1$ 44.42		$\sin u$	8.4824431
		°	$1 - \frac{P}{r^2}$	9.9993916
Time of beginning,	2:30 p. m.	Temp., 72		
Time of ending,	2:55 p. m.	Temp., 70.5		
		70		
Mean,	2:43 p. m.	$t = 70.8$	$\frac{m}{H}$	8.1808047

MAGNETIC OBSERVATIONS. HORIZONTAL INTENSITY.

DEFLECTIONS WITH THEODOLITE MAGNETOMETER.

Date: December 4, 1889.
Station: Asuncion Island, Loewer California.
Instrument: Theodolite magnetometer No. 2.
Magnet No. 2, deflecting at right angles to magnet No. 4, suspended.
Observer: Lieut. Charles F. Pond, U. S. Navy.

Distance $r = 1.5$ feet. log. $r = 0.1760913$.

Magnet.	North end.	Circle readings. No.	A	B	Mean.	Circle readings. No.	A	B	Mean.
			° ′	′	′		° ′	′	′
East.	E.	1	275 17	15.5	16.25				
	W.					2	274 15	14	14.50
	E.	3	275 17	15.5	16.25				
	W.					4	274 15	14	14.50
	E.	5	275 17	15.5	16.25				
	Mean,				16.25				14.50
West.	W.					6	274 13.5	13	13.25
	E.	7	275 16	15	15.50				
	W.					8	274 13.5	13	13.25
	E.	9	275 16	15	15.50				
	W.					10	274 13.5	13	13.25
	Mean,				15.50				13.25

Computation: $\frac{m}{H} = \frac{1}{2} r^3 \sin u \left(1 - \frac{P}{r^2} \cdots\cdots\right)$ $P = +0.00140$

			Logarithms.
Magnet east,	$2u = 1\ 1.75$		
Magnet west,	$2u = 1\ 2.25$	$\frac{1}{2}$	9.69897
Mean,	$1\ 2.00$	r^3	0.5282739
	$u = 31.00$	$\sin u$	7.9552451 $t = 70°.8$
		$1 - \frac{P}{r^2}$	9.9997297
Time of beginning,	2:56 p.m. Temp., 70		
Time of ending,	3:12 p.m. Temp., 70		
	70		
Mean,	3:04 p.m. $t = 70$	$\frac{m}{H}$	8.1822187
		Mean, $\frac{m}{H}$	8.1815120

HORIZONTAL INTENSITY.

OBSERVATIONS OF VIBRATIONS.

Date: December 2, 1889.
Station: Asuncion Island, Lower California.
Magnet No. 2 suspended; inertia ring not used.
Chronometer: Eggerts' Sons, 468; daily rate +1.6 seconds losing on mean time.
Observer: Lieut. Charles F. Pond, U. S. Navy.
Observation spot: Latitude, 27° 06′ 30″ N.; longitude, 114° 17′ 40″ W.

Number of vibrations.	Time.	Temp. t'	Extreme scale-readings.		Time of 100 vibrations.
	h. m. s.	°	d.	d.	m. s.
0	2 26 14.2	82	12.0	38.0	.....
10	26 48.7	.....	.....	.....	.....
20	27 23.1	.....	.....	.....	.....
31	28 01.1	.....	.....	.....	.....
41	28 35.6	.....	.....	.....	.....
51	2 29 10.0	.....	.....	.....	.....
	.....	83	15.6	34.5	.....
100	2 31 58.8	.....	.....	.....	5 44.6
110	32 33.2	.....	.....	.....	44.5
120	33 07.7	.....	.....	.....	44.6
131	33 45.6	.....	.....	.....	44.5
141	34 20.1	.....	.....	.....	44.5
151	2 34 54.5	83	18.0	32.1	44.5
Means		82.7	.....	.....	5 44.533

Coefficient of torsion. Value of one scale div. = 6′.25

Tors. cir.	Scale.	Diff.		Log.
			$v' = 1'.25$	
330	18.0 32.1 25.05			
60	20.1 30.1 25.10	0.05	$5400' + v'$ 5400 (ar. co.)	3.73249 6.26761
240	20.3 29.1 24.70	0.40	$1 + \frac{h}{F}$	0.00010
330	21.0 29.1 25.05	0.35		
Mean = v =		0.20		

HORIZONTAL INTENSITY.

CALCULATION.

$$T^2 = T'^2 \left(1 + \frac{k}{F}\right)(1 - (t' - t)q)$$

		s.
Observed time of 100 vibrations	=	344.533
Time of 1 vibration	=	3.44533
Correction for rate	= +	.00007
	T' =	3.44540

The chronometer used in this observation was about 1 minute slow of 120th meridian time.

			Log.
q	.00047	T'	0.5372396
$t' - t$	+4.7	T'^2	1.07448
$(t' - t)q$	.....	$1 + \frac{k}{F}$	0.00010
$1 - (t' - t)q$	0.99779	$1 - (t' - t)\,q$	9.99904
$mH = \frac{\pi^2 K}{T^2}$		T^2	1.07362
		$\pi^2 K$	0.93791
		mH	9.86429
		m	9.02210
		$= H$	0.84219

*Observations of deflections. Date: December 2, 1889, 3:20 to 4 p. m.

		$\log m$	
		H	8.17991
		mH	9.86429
		m^2	8.04420
$t = 78°$		m	9.02210 = 0.10522

HORIZONTAL INTENSITY.

OBSERVATIONS OF VIBRATIONS.

Date: December 2, 1889.
Station: Asuncion Island, Lower California.
Magnet No. 2 suspended; inertia ring not used.
Chronometer: Eggerts' Sons, 468; daily rate +1.6 seconds losing on mean time.
Observer, Lieut. Charles F. Pond, U. S. Navy.
Observation spot: Latitude, 27° 06′ 30″ N.; longitude, 114° 17′ 40″ W.

Number of vibrations.	Time.	Temp. t'	Extreme scale-readings.		Time of 102 vibrations.
	h. m. s.	°	d.	d.	m. s.
0	2 49 42.3	81.5	11.9	38.3	.....
10	50 16.7	.....	.....	.....	.....
20	50 57.2	.....	.....	.....	.....
31	51 29.0	.....	.....	.....	.....
41	52 03.5	.....	.....	.....	.....
51	2 52 38.0	.....	.....	.....	.....
	.....	81	15.0	35.1	.....
102	2 55 33.5	.....	.....	.....	5 51.2
112	56 08.0	.....	.....	.....	51.3
122	56 42.5	.....	.....	.....	51.3
133	57 20.4	.....	.....	.....	51.4
143	57 54.7	.....	.....	.....	51.2
153	2 58 29.2	79.5	17.6	32.5	51.2
Means.....		.....	.....	.....	5 51.267

Coefficient of torsion. Value of one scale div. = 6′.25

Tors. cir.	Scale.	Diff.		Log.
330	17.6 32.5 25.05		$v' = 1'.19$	
60	18.5 31.8 25.15	0.10	$5400' + v'$ 5400 (ar. co.)	3.73249 6.26761
140	18.5 31.1 24.80	0.35	$1 + \frac{h}{F}$	0.00010
330	19.1 31.1 25.10	0.30		
	Mean = v =	0.19		

HORIZONTAL INTENSITY.

CALCULATION.

$$T^2 = T'^2 \left(1 + \frac{h}{F}\right) (1 - (t' - t)q)$$

		s.
Observed time of 102 vibrations	=	351.267
Time of 1 vibration	=	3.44378
Correction for rate	=	.00007
	T' =	3.44385

The chronometer used in this observation was about 1 minute slow of 120th meridian time.

			Log.
q	.00047	T'	0.5370442
$t' - t$	+2.7	T'^2	1.07409
$(t' - t)q$	.....	$1 + \frac{h}{F}$	0.00010
$1 - (t' - t)q$	0.99873	$1 - (t' - t)\,q$	9.99945
$mH = \frac{\pi^2 K}{T^2}$		T^2	1.07364
		$\pi^2 K$	0.93790
		mH	9.86426
		m	9.02208
		6.9531 = H	0.84218

* Observations of deflections. Date: December 2, 1889, 3:20 to 4 p. m.

		$*\frac{m}{H}$	8.17991
		mH	9.86426
		m^2	8.04417
	$t = 78°$	m	9.02208 = 0.10522

HORIZONTAL INTENSITY.

Observations of Vibrations.

Date: December 3, 1889.
Station: Asuncion Island, Lower California.
Magnet No. 2, suspended; inertia ring not used.
Chronometer: Eggerts' Sons, 468; daily rate + 2.4 seconds losing on mean time.
Observer: Lieut. Charles F. Pond, U. S. Navy.
Observation spot: Latitude, 27° 06′ 30″ N.; longitude, 114° 17′ 49″ W.

Number of vibrations.	Time.	Temp. t'	Extreme scale-readings.		Time of 100 vibrations.
	h. *m.* *s.*	°	*d.*	*d.*	*m.* *s.*
0	8 46 10.1	77.5	10.4	.....	.....
10	46 44.5	.....	.....	.....	.....
20	47 18.9	.....	.....	.....	.....
31	47 56.8	.....	.....	.....	.....
41	48 31.2	.....	.....	.....	.....
51	8 49 05.6	.....	.....	.....	.....
	.....	77.5	14.0	36.0	.....
100	8 51 54.1	.....	.....	.....	5 44.1
110	52 28.6	.....	.....	.....	44.1
120	53 03.0	.....	.....	.....	44.1
131	53 41.0	.....	.....	.....	44.2
141	54 15.4	.....	.....	.....	44.2
151	8 54 49.7	77.5	16.9	33.1	44.1
Means		77.5	.....	.....	5 44.133

Coefficient of torsion. Value of one scale div. = 6′.25

Tors. cir.	Scale.	Diff.		Log.
			$v' = 1'.75$	
240	16.9 33.1 / 25.00			
330	18.7 32.0 / 25.35	0.35	$5400' + v'$	3.73253
			5400 (ar. co.)	6.26761
150	18.6 31.0 / 24.80	0.55	$1 + \frac{h}{F}$	0.00014
	1.9 31.0 / 25.00	0.20		
Mean = v =		0.28		

HORIZONTAL INTENSITY.

CALCULATION.

$$T^2 = T'^2 \left(1 + \frac{h}{F}\right)(1 - (t' - t)q)$$

		s.
Observed time of 100 vibrations	=	344.183
Time of 1 vibration	=	3.44133
Correction for rate	= +	.0001
	T' =	3.44143

The chronometer used in this observation was about 2 minutes slow of 120th meridian time.

			Log.
		T'	0.5367390
q	.....	T'^2	1.07348
$t' - t$	.....	$1 + \frac{h}{F}$	0.00014
$(t' - t)q$	.....	$1 - (t' - t)q$	0.00086
$1 - (t' - t)q$	.....	T^2	1.07448
$mH = \frac{\pi^2 K}{T^2}$		$\pi^2 K$	0.93788
		mH	9.86340
		m	9.02104
		6.9560 = H	0.84236

*Observations of deflections. Date: December 3, 1889, 9:37 to 10:30 a. m.

	$\frac{*m}{H}$	8.17868
	mH	9.86340
	m^2	8.04208
$t = 81°.7$	m	9.02104 = 0.10496

HORIZONTAL INTENSITY.

OBSERVATIONS OF VIBRATIONS.

Date: December 3, 1889.
Station: Asuncion Island, Lower California.
Magnet No. 2 suspended; inertia ring not used.
Chronometer: Eggerts' Sons, 468; daily rate + 2.4 seconds losing on mean time.
Observer: Lieut. Charles F. Pond, U. S. Navy.
Observation spot: Latitude, 27° 06′ 30″ N.; longitude, 114° 17′ 40″ W.

Number of vibrations.	Time.	Temp. t'	Extreme scale-readings.		Time of 100 vibrations.
	h. *m.* *s.*	°	*d.*	*d.*	*m.* *s.*
0	9 06 56.2	78	12.7	37.3	.....
10	07 30.6	.....	.....	.....	.....
20	08 05.0	.....	.....	.....	.....
31	08 42.9	.....	.....	.....	.....
41	09 17.7	.....	.....	.....	.....
51	9 09 51.9	.....	.....	.....	.....
	.....	78.5	15.9	34.1	.....
100	9 12 40.5	.....	.....	.....	5 44.3
110	13 14.9	.....	.....	.....	44.3
120	13 49.3	.....	.....	.....	44.3
131	14 27.2	.....	.....	.....	44.3
141	15 01.6	.....	.....	.....	44.2
151	9 15 36.1	79	18.0	31.9	44.2
Means.....		78.5	.....	.....	5 44.267

Coefficient of torsion. Value of one scale div. = 6′.25

Tors. cir.	Scale.	Diff.		Log.
			$v' = 1'.75$	
240	18.0 31.9 / 24.95			
330	20.2 30.1 / 25.15	0.20	$5400' + v'$	3.73253
			5400 (ar. co.)	6.26761
150	20.1 29.1 / 24.60	0.55	$1 + \frac{h}{F}$	0.00014
240	20.8 29.1 / 24.95	0.35		
Mean = v =		0.28		

HORIZONTAL INTENSITY.

CALCULATION.

$$T^2 = T'^2 \left(1 + \frac{h}{F}\right) (1 - (t' - t)q)$$

		s.
Observed time of 100 vibrations	=	344.267
Time of 1 vibration	=	3.44267
Correction for rate	= +	.0001
	T' =	3.44277

The chronometer used in this observation was about 2 minutes slow of 120th meridian time.

			Log.
		T'	0.536908
q	.00047	T'^2	1.07382
$t' - t$	.....	$1 + \frac{h}{F}$	0.00014
$(t' - t)q$	.....	$1 - (t' - t)q$	0.00065
$1 - (t' - t)q$	.....	T^2	1.07461
		$\pi^2 K$	0.93788
$mH = \frac{\pi^2 K}{T^2}$		mH	9.86327
		m	9.02098
		$6.9549 = H$	0.84229

*Observations of deflections. Date: December 3, 1889, 9:37 to 10:30 a. m.

	$*m$	8.17868
	H	
	mH	9.86327
	m^2	8.04195
$t = 81°.7$	m	$9.02098 = 0.10495$

HORIZONTAL INTENSITY.

OBSERVATIONS OF VIBRATIONS.

Date: December 4, 1889.
Station: Asuncion Island, Lower California.
Magnet No. 2 suspended; inertia ring not used.
Chronometer: Eggerts' Sons, 468; daily rate, +2.1 seconds losing on mean time.
Observer: Lieut. Charles F. Pond, U. S. Navy.
Observation spot: Latitude, 27° 06′ 30″ N.; longitude, 114° 17′ 40″ W.

Number of vibrations.	Time.	Temp. t'	Extreme scale-readings.		Time of 100 vibrations.
	h. *m.* *s.*	°	*d.*	*d.*	*m.* *s.*
0	1 54 20.2	74.5	13.2	36.8	.....
10	54 54.6	.....	.....	.....	.....
20	55 29.0	.....	.....	.....	.....
31	56 06.6	.....	.....	.....	.....
41	56 41.0	.....	.....	.....	.....
51	1 57 15.4	.....	.....	.....	.....
	.....	74.5	16.3	33.7	.....
100	2 00 03.3	.....	.....	.....	5 43.1
110	00 37.6	.....	.....	.....	43.0
120	01 12.0	.....	.....	.....	43.0
131	01 49.7	.....	.....	.....	43.1
141	02 24.1	.....	.....	.....	43.1
151	2 02 58.4	74.0	18.5	31.5	43.0
Means.....		74.3	.....	.....	5 43.05

Coefficient of torsion. Value of one scale div. = 6′.25

Tor. cir	Scale.	Diff.		Log.
			$v' = 1'.19$	
See next set.				
			$5400' + v'$	3.73249
			5400 (ar. co.)	6.26761
			$1 + \frac{h}{F}$	0.00010
Mean = v =		0.19		

HORIZONTAL INTENSITY.

CALCULATION.

$$T^2 = T'^2 \left(1 + \frac{h}{F}\right) \quad (1 - (t' - t)\, q)$$

	s.
Observed time of 100 vibrations	= 343.05
Time of 1 vibration	= 3.43
Correction for rate	= 0.00
	T′ = 3.4305

The chronometer used in this observation was about 2 minutes slow of 120th meridian time.

			Log.
		T′	0.5353636
q	.00047		
$t' - t$	+3.5	T'^2	1.07073
$(t' - t)\, q$	.....	$1 + \frac{h}{F}$	0.00010
$1 - (t' - t)\, q$	0.99836	$1 - (t' - t)\, q$	9.99928
		T^2	1.07011
$mH = \frac{\pi^2 K}{T^2}$		$\pi^2 K$	0.93787
		mH	9.86776
		m	9.02464
		6.9682 = H	0.84312

* Observations of deflections. Date: December 4, 1889, 2:30 to 3:12 p. m.

		$\frac{*m}{H}$	8.18151
		mH	9.86776
		m^2	8.04927
$t = 70°.8$		m	9.02464 = 0.10584

HORIZONTAL INTENSITY.

Observations of Vibrations.

Date: December 4, 1889.
Station: Asuncion Island. Lower California.
Magnet No. 2 suspended; inertia ring not used.
Chronometer: Eggerts' Sons, 468; daily rate + 2.1 seconds losing on mean time.
Observation spot: Latitude, 27° 6′ 30″ N.; longitude, 114° 17′ 40″ W.

Number of vibrations.	Time.	Temp. t'	Extreme scale-readings.		Time of 100 vibrations.
	h. m. s.	°	d.	d.	m. s.
0	2 7 09.1	74	10.7	39.3	.....
10	7 43.4	.....	.....	.....	.....
20	8 17.7	.....	.....	.....	.....
31	8 55.5	.....	.....	.....	.....
41	9 29.8	.....	.....	.....	.....
51	10 04.2	.....	.....	.....	.....
	.....	74	14.0	36.0	.....
100	2 12 52.1	.....	.....	.....	5 43.0
110	13 26.5	.....	.....	.....	43.1
120	14 00.8	.....	.....	.....	43.1
131	14 38.6	.....	.....	.....	43.1
141	15 12.9	.....	.....	.....	43.1
151	2 15 47.2	73.5	17.0	33.0	43.0
Means.....		73.8	.....	.....	43.067

Coefficient of torsion. Value of one scale div. = 6′.25

Tors. cir.	Scale.	Diff.		Log.
			$v' = 1'.19$	
190	17.0 33.0 / 25.00			
280	17.9 32.7 / 25.30	0.30	$5400' + v'$ / 5400 (ar. co.)	3.73249 / 6.26761
100	18.0 31.9 / 24.95	0.35	$1 + \frac{h}{F}$	0.00010
190	18.9 31.2 / 25.05	0.10		
Mean = v =		0.19		

HORIZONTAL INTENSITY.

CALCULATION.

$$T^2 = T'^2 \left(1 + \frac{h}{F}\right) \quad (1 - (t' - t)\, q)$$

		s.
Observed time of 100 vibrations	=	343.067
Time of 1 vibration	=	3.43067
Correction for rate	=	+ .00008
	T' =	3.43075

The chronometer used in this observation was about 2 minutes slow of 120th meridian time.

			Log.
		T'^2	0.535389
q	.00047		
$t' - t$	+3.0	T'^2	1.07078
$(t' - t)\, q$	.....	$1 + \frac{h}{F}$	0.00010
$1 - (t' - t)\, q$	0.99859	$1 - (t' - t)\, q$	9.99939
		T^2	1.07027
$mH = \frac{\pi^2 K}{T^2}$		$\pi^2 K$	0.93786
		mH	9.86759
		m	9.02455
		6.9522 = H	0.84304

*Observations of deflections. Date: December 4, 1889, 2:30 to 3:12 p. m.

	$\frac{*m}{H}$	8.18151
	mH	9.86759
	m^2	8.04910
$t = 70°.8$	m	9.02455 = 0.10582

The computation of the foregoing observations gives the following values:

Date.	Declination.	Dip.	Horizontal intensity (British units).
December 4, 1889.....	10° 58′.5 E.	51° 53′	6.9587

The following additional observations of the declination have been collected with a view of deducing an empirical equation for predicting values of the declination and assigning rates of secular change at this station:

Year.	Declination.	Authority.	Reference.
	° ′		
1783	8 00 E.	.....	Appendix 7, Coast and Geodetic Survey Report, 1888, p. 266, *et seq.*
1839	10 30	Capt. Kellet, Royal Navy...	Proceedings Royal Society, 1875. Observed at San Bartolome Bay as 10° 46′ E., and reduced to Asuncion by subtracting 16′.
1873.2	11 26.4	Wm. Eimbeck, Assistant, U. S. Coast and Geodetic Survey.	Appendix 7, as above.
1881.2	11 23	Lieut. Commander H. E. Nichols, U. S. Navy.	Hydrographic Office Archives, Section IV, Box 5, Index 850 E.

The secular change in the magnetic declination can be represented with considerable accuracy by a periodic function of the form

$$V = A + B_1 \sin \frac{360}{m} t + B_2 \cos \frac{360}{m} t,$$

in which V represents the declination or variation; m, the period of the cycle which, in this case, has been found by trial and by the investigations at surrounding stations to be 240 years; t, the time in years and fractions of a year reckoned from 1850, plus when forward, minus when backward; and A, B_1, and B_2, constants which are to be found from the observations by the method of least squares.

From the observations the following conditional equations are formed:

°	A		B_1		B_2	
− 8.000	= 1.000	+ sin (1.5 ×	−67)	+ cos (1.5 ×	−67)
−10.500	= 1.000	+ sin (1.5 ×	−11)	+ cos (1.5 ×	−11)
−11.440	= 1.000	+ sin (1.5 ×	23.2)	+ cos (1.5 ×	23.2)
−11.380	= 1.000	+ sin (1.5 ×	31.2)	+ cos (1.5 ×	31.2)
−10.980	= 1.000	+ sin (1.5 ×	39.9)	+ cos (1.5 ×	39.9)

or

	A		B_1		B_2	
°			° ′		° ′	
− 8.000	= 1.000	+ sin	−100 30	+ cos	−100 30	
−10.500	= 1.000	+ sin	− 16 30	+ cos	− 16 30	
−11.440	= 1.000	+ sin	− 34 48	+ cos	− 34 48	
−11.380	= 1.000	+ sin	− 46 48	+ cos	− 46 48	
−10.980	= 1.000	+ sin	− 59 51	+ cos	− 59 51	

or

$$\begin{array}{rrrr} o & A & B_1 & B_2 \\ -8.000 = & 1.000 & -.983 & -.182 \\ -10.500 = & 1.000 & -.284 & +.959 \\ -11.440 = & 1.000 & +.571 & +.821 \\ -11.380 = & 1.000 & +.729 & +.684 \\ -10.980 = & 1.000 & +.864 & +.502 \end{array}$$

From these conditional equations the following normal equations have been formed:

Normal for A, found by adding the conditional equations:

$$-52.300 = +5.000\,A + 0.897\,B_1 + 2.784\,B_2 \quad (a)$$

Normal for B_1:

$$\begin{array}{l} +7.864 = -.983\,A + .966\,B_1 + .179\,B_2 \\ +2.982 = -.284\,A + .081\,B_1 - .272\,B_2 \\ -6.532 = +.571\,A + .326\,B_1 + .469\,B_2 \\ -8.296 = +.729\,A + .531\,B_1 + .499\,B_2 \\ -9.487 = +.864\,A + .746\,B_1 + .434\,B_2 \\ \hline -13.469 = +0.897\,A + 2.650\,B_1 + 1.309 \quad (b_1) \end{array}$$

Normal for B_2:

$$\begin{array}{l} +1.456 = -.182\,A + .179\,B_1 + .033\,B_2 \\ -10.069 = +.959\,A - .272\,B_1 + .920\,B_2 \\ -9.392 = +.821\,A + .469\,B_1 + .674\,B_2 \\ -7.784 = +.684\,A + .499\,B_1 + .468\,B_2 \\ -5.512 = +.502\,A + .434\,B_1 + .252\,B_2 \\ \hline -31.301 = +2.784\,A + 1.309\,B_1 + 2.347 \quad (b_2) \end{array}$$

Eliminating:

$(a) \times 0.1794$ gives

$$\begin{array}{l} -9.383 = +0.897\,A + 0.161\,B_1 + 0.499\,B_2 \quad (1) \\ -13.469 = +0.897\,A + 2.650\,B_1 + 1.309\,B_2 \quad (b_1) \\ \hline -4.086 = \qquad\qquad +2.489\,B_1 + 0.810\,B_2 \quad (2) \end{array}$$

$(a) \times .5568$ gives

$$\begin{array}{l} -29.121 = +2.784\,A + 0.499\,B_1 + 1.550\,B_2 \quad (3) \\ -31.301 = +2.784\,A + 1.309\,B_1 + 2.347\,B_2 \quad (b_2) \\ \hline -2.180 = \qquad\qquad +0.810\,B_1 + 0.797\,B_2 \quad (4) \end{array}$$

$(4) \times 3.0728$ gives

$$\begin{array}{l} -6.699 = +2.489\,B_1 + 2.449\,B_2 \quad (5) \\ -4.086 = +2.489\,B_1 + 0.810\,B_1 \quad (2) \\ \hline -2.613 = \qquad\qquad +1.639\,B_2 \quad (6) \end{array}$$

$$B_2 = -\frac{2.613}{1.639} = -1.594$$

Substituting the value of B_2 in (2),

$$-4.086 = +2.489\,B_1 + 0.810 \times -1.594$$
$$= +2.489\,B_1 - 1.291$$
$$-2.795 = +2.489\,B_1$$

$$B_1 = -\frac{2.795}{2.489} = -1.123$$

Substituting the values of B_1 and B_2 in (a),

$$-52.300 = +5.000\,A - 1.007 - 4.438$$
$$-46.855 = +5.000\,A$$

$$A = -9.371$$

$$\therefore V = -9.371 - 1.123 \sin 1.5\,t - 1.594 \cos 1.5\,t$$

$$V_{1783} = 7.977 = -9.371 + 1.104 + 0.290$$
$$V_{1839} = 10.581 = -9.371 + 0.319 - 1.529$$
$$V_{1873.2} = 11.321 = -9.371 - 0.641 - 1.309$$
$$V_{1881.2} = 11.280 = -9.371 - 0.819 - 1.090$$
$$V_{1889.9} = 11.141 = -9.371 - 0.970 - 0.800$$

Year.	Observed.	Computed.	v	v^2
1783	8.00	7.98	−0.02	0.000
1839	10.50	10.58	−0.08	0.006
1873.2	11.44	11.32	−0.12	0.014
1881.2	11.38	11.28	−0.10	0.010
1889.9	10.98	11.14	−0.16	0.026
			$\Sigma v^2 =$	0.056

Probable error of a single observation=

$$.6745\sqrt{\frac{0.056}{2}} = \pm .6745 \times .17 = \pm 0.115 = \pm 0^\circ\ 07'$$

Differentiating the equation giving the variation for any year, it becomes

$$\frac{dV}{dt} = -1.123 \times 1.5 \cos 1.5\,t - 1.594 \times 1.5 \sin 1.5\,t$$
$$= -1.685 \cos 1.5\,t - 2.391 \sin 1.5\,t$$

Multiplying by sin 1° to convert the circular measure into arc, and by 60 to convert the result into minutes, the secular change for any year becomes

$$60 \sin 1^\circ\,[-1.685 \cos 1.5\,t - 2.391 \sin 1.5\,t]$$

Thus the secular change of the variation for 1891 is

$$60 \sin 1^\circ\,[-1.685 \cos 1.5 \times 41 - 2.391 \sin 1.5 \times 41]$$

$$1.047\,(-1.685 \times .477 - 2.391 \times 879)$$

$$1.047\,(-.803 - 2.102)$$

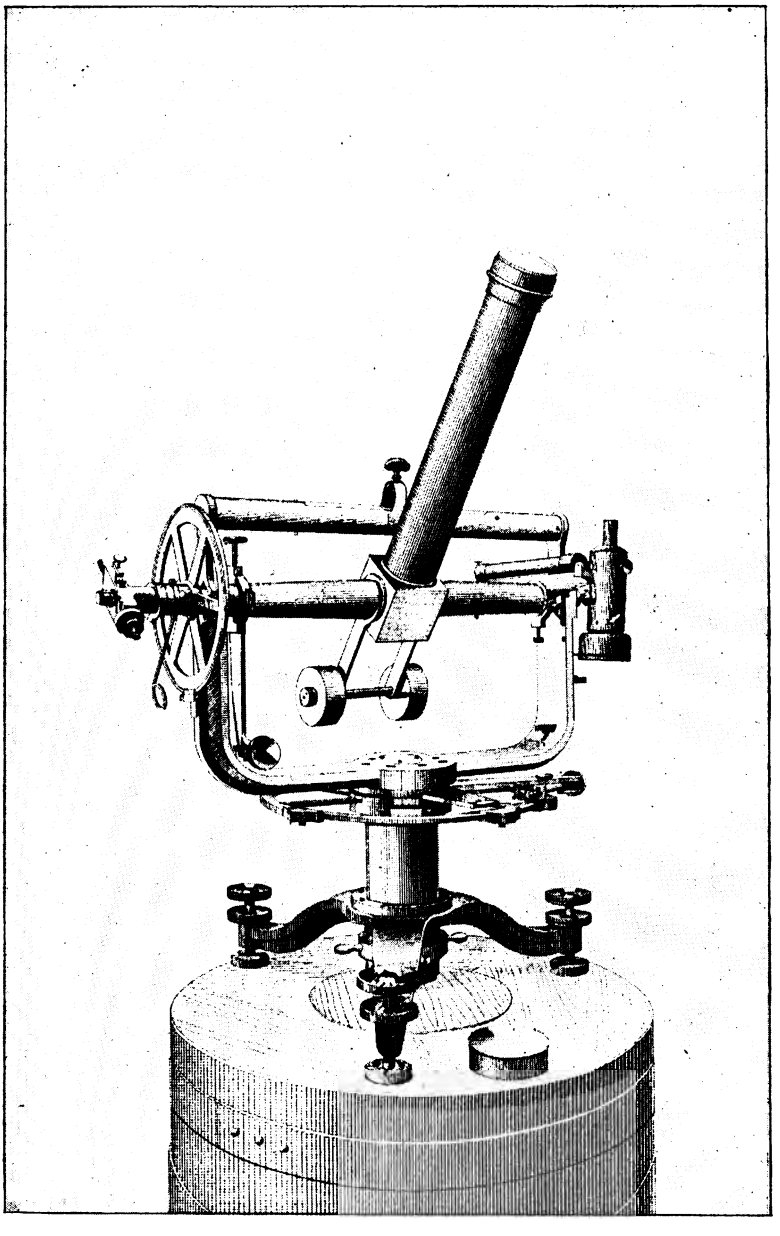
$$1'.36 \text{ (decreasing)}$$

CHAPTER V.

THE DETERMINATION OF THE ASTRONOMICAL POSITION OF ABREOJOS POINT.

The observations for latitude and longitude were made by Lieut. C. W. Bartlett, U. S. Navy, who also reduced them.

The instrument known as Hydrographic Office Transit No. 2, a combination of the transit instrument and zenith telescope designed by Mr. J. A. Rogers in 1873 was used for the determination of both latitude and time. (See plate.) It is of 30 inches focal length, with an object glass of 2½ inches clear aperture, and is so constructed that the eyepiece is at one end of the horizontal axis, a prism at the junction of the telescope tube and axis reflecting at a right angle the rays from the object glass, thereby enabling the observer to direct the instrument upon stars of any altitude above the horizon without changing his position. The tripod and vertical cylinder above it are of cast iron; the rest of the metal is bronze. The transverse arms which support the ends of the telescope axis are firmly screwed to the top of a vertical and slightly conical axis, which revolves in the cylinder surmounting the tripod. A small universal level over the head of this axis is of use in leveling the instrument approximately. The horizontal circle is 14 inches in diameter, has two verniers, and reads to 10″. It is furnished with a clamp and tangent screw for slow azimuthal motion, and with two sliding stops, which, when fastened at the proper points on the circle, enable the telescope to be turned exactly 180° in azimuth for zenith telescope observations for latitude. A powerful clamp at the lower end of the vertical axis fixes it firmly in its seat when the instrument is adjusted in the meridian or prime vertical. By means of the horizontal circle the instrument can be readily turned 90° from the meridian into the prime vertical, a feature of great importance when, from absence of a list to select proper stars from, or from any other cause, the zenith telescope method of determining latitude is not available. The horizontal axis has a vertical finding circle 8 inches in diameter reading to minutes, and on the opposite end of the axis is a transverse level for indicating any change in inclination of the telescope from the vertical. This level, with a filar micrometer of the usual form attached to the eyepiece, forms the zenith telescope attachment for the determination of latitude.



The eyepiece is of a Ramsden pattern, magnifying about eighty diameters and has a parallactic motion across the field, so that stars may be observed accurately over each of the seventeen transit lines if desired.

The bearing of the Ys which support the axis are segmental in shape and have no micrometric attachment for either level or azimuthal adjustment.

A small spot 0.2 inch in diameter, ground on the reflecting face of the prism, permits the transmission of rays of light from the lamp at the end of the axis to illuminate the threads in the eyepiece. Originally these threads were eleven in number, with three transverse micrometer threads, but much annoyance arising from their breakage the transit threads were replaced, in the summer of 1875, by glass diaphragms, on which lines for transit observations were ruled with accuracy by W. A. Rogers, esq., of Harvard Observatory. In addition to these transit lines, diagonal lines were ruled across the glass plate at equal distances to use instead of the micrometer for determining differences of zenith distances of stars should the micrometer threads be broken.

The end of the tube which carries the micrometer box fits accurately against a movable collar on the axis in such a way that when the instrument is adjusted to stellar focus the collar can be screwed up against this shoulder, preventing this adjustment from disturbance.

Striding levels are provided for the horizontal axis, having divisions on the glass tube about 1 millimeter apart, equal to 0.94 seconds of arc or 0.063 seconds of time.

This instrument is packed compactly in two boxes and, as when mounted it only weighs 125 pounds, it is easily transported.

LONGITUDE OBSERVATIONS.

CHRONOGRAPH.

The registering of the times of transit of stars or of the occurrence of time signals was performed by an electric chronograph. In this instrument a train of wheel work, driven by a weight, causes a cylinder about 6½ inches in diameter and 7 inches long and covered with a sheet of paper, easily put on and taken off, to make exactly one revolution in a minute.

A little carriage, to which a pen of peculiar construction is attached, moves upon wheels along the cylinder in the direction of its length about one-tenth of an inch for each revolution of the cylinder, so that the pen records a perpetual spiral. The pen is so mounted as to have a slight lateral movement, and is so attached to an electro-magnet that when the electric circuit in which it is placed is broken every second by the chronometer, which, with a small battery, is included in the same circuit, the mark made on the chronograph paper, instead of being a straight line, will be broken at regular intervals. By means

of a break-circuit key in the hands of the observer, and included in the same circuit, the electric current may be interrupted, causing the pen to make a similar mark on the occurrence of any event, such as the passage of a star across any of the wires of the telescope.

When the sheet of the cylinder becomes full it is taken off, and by means of a finely divided scale the positions of these arbitrary marks, with reference to the nearest second marks, may be accurately and easily determined. A screw at the bottom of the pendulum affords an easy method of regulating the clockwork, either for faulty running or for changes of latitude. For a description of the peculiar spring-governor escapement of this chronograph, see Brunnow's Astronomical Notices, p. 164, and Vol. I, Annals of Cambridge Observatory.

CHRONOMETERS.

One break-circuit sidereal chronometer was used at the observatory and taken on shore with the instruments. With this all observations were taken.

One mean-time break-circuit chronometer was carried, in case of accident to the sidereal chronometer. On board the ship were eight mean-time box chronometers, which were never moved from the chronometer room, and one Hack chronometer.

PORTABLE OBSERVATORY.

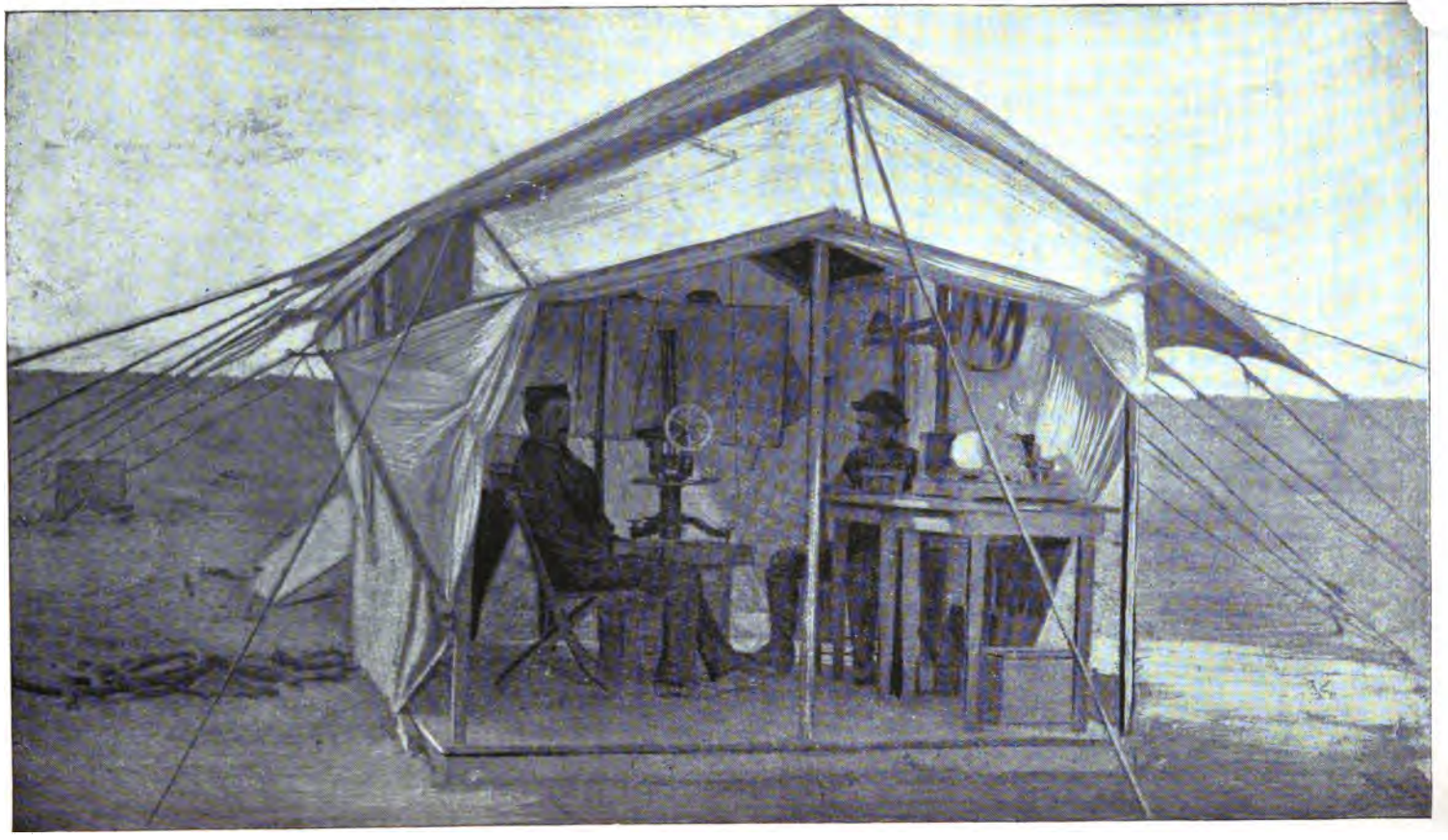
To shelter the instruments and observers there was furnished an observing tent, designed by Lieut. J. A. Norris, U. S. Navy, for use in the expeditions sent out under his command by the Navy Department, for the telegraphic determination of longitudes in the West Indies and Central America. It was set on a solid foundation of sills floored over. A slit 1 foot wide, commencing 3 feet from the floor, extended across the roof from side to side, 4 feet from one of the ends. This arrangement gave sufficient sweep for the transit instrument in both azimuth and altitude, and allowed ample space at the other end of the tent for the tables, chronometers, and chronograph. Three tables, capable of being taken apart for packing, were furnished with the tent.

TRANSIT PIER.

A pier of brick and cement was built as a foundation for the transit instrument. After it had stood one day the tent and instruments were set up and the electric-current wires were run.

METHOD OF OBSERVATION.

The transit instrument was mounted and placed approximately in the meridian, leveled in all directions by means of the circular level in the center of the base, and adjusted in the direction of the axis by means of the striding level. The collimation was adjusted by sighting a distant object. The approximate local sidereal time was known from



THE ASTRONOMICAL OBSERVING TENT.

the approximate longitude and the error and rate of the chronometer. The transit instrument was first pointed to Polaris; then set to the zenith distance of a slow-moving star, the zenith distance and time of culmination having been computed. A short time before culmination, having come into the field, the star would be followed on the middle thread by turning the azimuth screw until the time of culmination, when the instrument would point very close to the meridian. A still closer adjustment may be made by a repetition of the same process. If the local time is not accurately known, by setting on the zenith distance of a zenith star, which is little affected by error in azimuth, and observing the time of meridian passage, a correction for the chronometer may be found. Then, with the corrected time, the adjustment may be made by observing a slow-moving star. The azimuth was adjusted several evenings by this method.

A list of all stars that culminated after sunset was arranged for the observations for time from the Berliner Jahrbuch and the American Ephemeris. It gave the magnitude, position, time of culmination, right ascension, declination, and zenith distance. The position and zenith distance depend upon the latitude and are computed from the formula $z = \pm \varphi \mp d, \begin{matrix} S \\ N \end{matrix}$ of the zenith. The others are taken directly from the Almanac. The time of culmination may be computed, knowing the right ascension and the error of the chronometer for each evening.

Each night two sets of stars were observed, one clamp east and one clamp west, between the times of comparison of the sidereal chronometer with the chronometers on board ship. Each set consisted of at least five time stars, preferring those nearest the zenith, and one or two circumpolar stars, the latter being used for determining the instrumental errors.

If possible, readings of the striding level were taken after each observation, as considerable change was found during an evening. The ship was distant from the tent about half a mile. As the landing was on an open beach, with a heavy surf breaking at all times, making it dangerous to transport the chronometers, they were compared by means of a flash light elevated above the deck and inclosed in a case with a shutter kept shut by a stiff spring operated by an observer in the chronometer room. The flashes were recorded on shore upon the chronograph as seen every ten seconds for a period of three minutes.

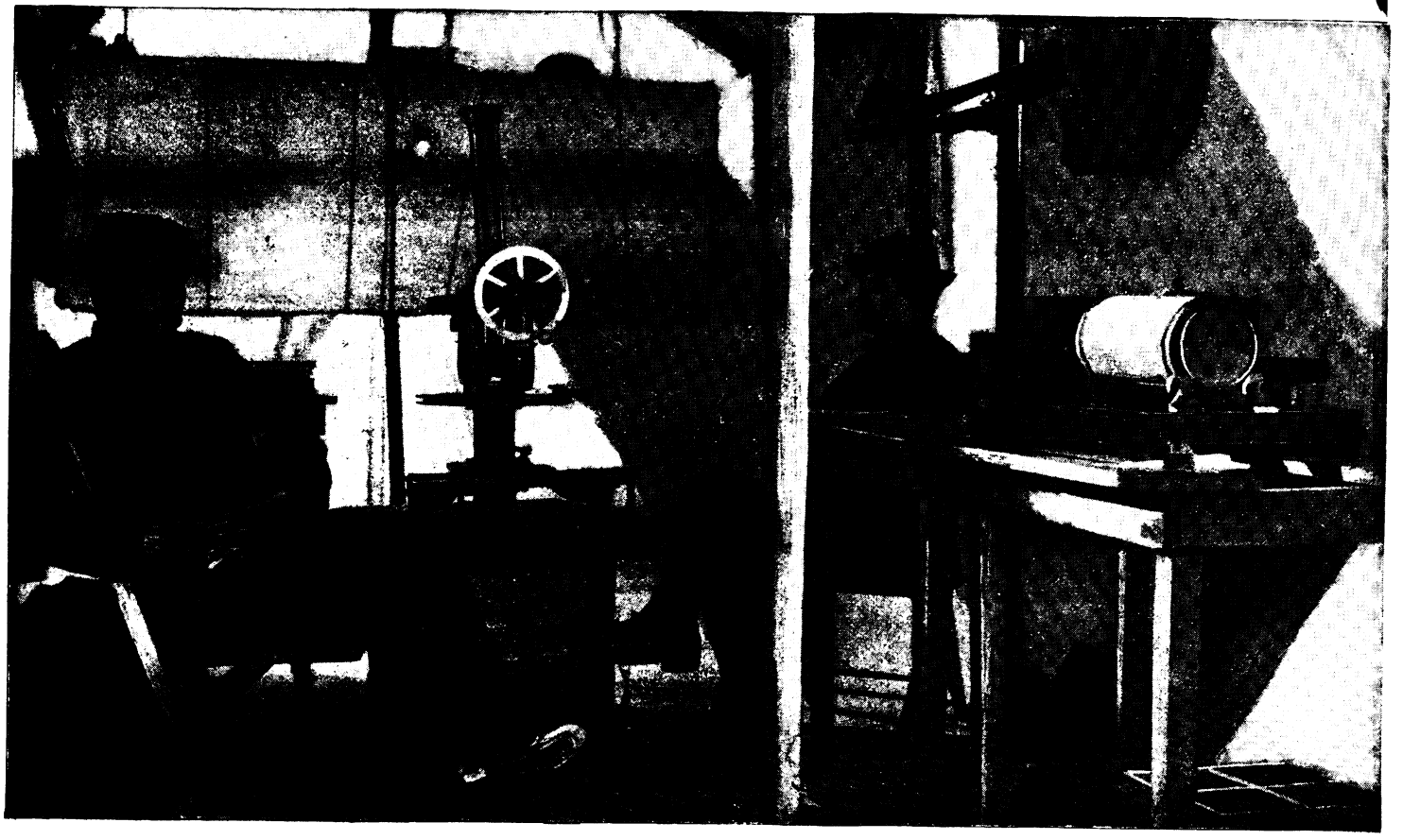
Observations were taken January 14, 20, 21, and 22 for time. On January 22 the vessel started for San Diego and arrived there January 26. The chronograph and break-circuit chronometer were immediately set up in the telegraph office to compare time with the observatory at the navy yard, Mare Island, previous arrangements having been made for that purpose. Owing to a flood the wires were down and comparisons were not obtained until January 29. They were continued on January 30, February 1, and February 3. The chronometer at the

telegraph office was compared with those on board ship by transporting a Hack chronometer. On February 4 the vessel left San Diego and returned direct to Abreojos Point, where, on February 10, the instruments were again set up and observations for time made.

A reduction of the work of each night was made by applying to the observed time of transit of each star, reduced to the mean of the threads, the corrections for level, flexure of the axis, inequality of the pivots, and hourly rate. The difference between the reduced meridian passage of each star and its right ascension gave a value for the reduction to determine the corrections for azimuth and collimation, solved by the method of least squares. Two values for the azimuth correction were found, one before and one after reversal. With these values a clock correction for each star was obtained. The mean of these corrections, rejecting circumpolar stars, gave a true correction for the set. The hourly rate was obtained and applied to each set to reduce to the time of comparison. All chronometers were compared about the time that the comparison was made between the ship's standard chronometer and the chronometer on shore, so that a local correction was found for all each evening. At San Diego, by comparison with the observatory at Mare Island, a correction for each chronometer was again found upon one hundred and twentieth meridian time. Upon the return to the original station a final correction upon local time at that place was found in the same manner as before.

By the observations at Abreojos Point, on January 14, 20, 21, and 22, the errors and rates of chronometers Nos. 1942, 1228, 1449, 1276, 1110, 1644, 1402, and 1639, at the mean epoch January 19^{d}.25, were as follows:

Chro.	C			δT
	h.	m.	s.	s.
1942...	− 7	02	37.48	+1.19
1228...	−11	21	04.045	−1.22
1449...	− 7	40	22.455	−1.24
1276...	− 7	35	11.28	−0.80
1110...	− 7	33	50.65	−0.19
1644...	− 7	39	30.44	−1.30
1402...	− 7	31	33.08	+0.59
1639...	− 7	31	53.05	+0.44



THE ASTRONOMICAL OBSERVING AND RECORDING INSTRUMENTS SET UP AT ABREOJOS POINT.

On arriving at San Diego the errors on mean time of the one hundred and twentieth meridian were found to be, on January 31.5—

Chro.	C_k			$\delta'T$
	h.	*m.*	*s.*	*s.*
1942...	— 7	28	03.78	+1.35
1228...	—11	47	04.08	—1.51
1449...	— 8	06	19.45	—1.21
1276...	— 8	01	04.75	—1.03
1110...	— 7	59	36.38	—0.19
1644...	— 8	05	28.98	—1.07
1402...	— 7	57	12.00	+0.17
1639...	— 7	57	29.48	+0.45

The meridian distance between the astronomical station at Abreojos Point and the one hundred and twentieth meridian is deduced by the formula

$$M = C_k - \left\{ C + t\delta T + \frac{t}{2} x \right\}$$

in which—

C_k = chro. error on L. M. T., Abreojos Pt., Jan. 19.25, L. M. T.; $\delta'T$ = rate
C = chro. error on L. M. T., 120th merid., Jan. 31.50, L. M. T.; δT = rate

$$\text{Elapsed time} = t = \overline{12.25},\ \delta'T - \delta T = x = \text{change of rate in } t$$

d

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Chronometer.	$\delta'T$ or $\delta T+x$	δT	$t\delta T$	x	$\frac{t}{2}x$	$t\delta T+\frac{t}{2}x$	C	$C+t\delta T+\frac{t}{2}x$	C_1	M
			(3)×12.25	(2)−(3)	(5)×6.125	(4)+(6)		(7)+(8)		(10)−(9)
	s.	*s.*					*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
1942	+1.35	+1.19	+14.57	+0.16	+0.98	+15.55	− 7 02 37.48	− 7 02 21.93	− 7 28 03.78	−0 25 41.85
1228	−1.51	−1.22	−14.94	−0.29	−1.77	−16.71	−11 21 04.055	−11 21 20.76	−11 47 04.08	−0 25 43.33
1449	−1.21	−1.24	−15.19	+0.03	+0.18	−15.01	− 7 40 22.46	− 7 40 37.46	− 8 06 19.45	−0 25 41.99
1276	−1.03	−0.80	− 9.80	−0.23	−1.40	−11.20	− 7 35 11.28	− 7 35 22.48	− 8 01 04.75	−0 25 42.27
1110	−0.19	−0.19	− 2.32	0.00	0.00	− 2.32	− 7 33 50.65	− 7 33 52.99	− 7 59 36.38	−0 25 43.41
1644	−1.07	−1.30	−15.92	+0.23	+1.40	−14.52	− 7 39 30.44	− 7 39 44.96	− 8 05 28.98	−0 25 44.02
1402	+0.17	+0.59	+ 7.22	−0.42	−2.57	+ 4.65	− 7 31 33.08	− 7 31 28.43	− 7 57 12.00	−0 25 43.57
1039	+0.45	+0.44	+ 5.39	+0.01	+0.61	+ 6.00	− 7 31 53.05	− 7 31 47.05	− 7 57 29.48	−0 25 42.43

	h.	*m.*	*s.*
Mean	−0	25	42.858
One hundred and twentieth meridian	8	00	00.000
Longitude W	=7	34	17.142

OBSERVATIONS FOR LATITUDE.

An observing list consisting of about thirty pairs of stars was prepared from "A catalogue of stars for observations of latitude," found in Appendix 7, Coast and Geodetic Survey Report for 1876. The zenith distances of the stars selected to form a pair did not differ more than twenty minutes of arc; and their times of culmination did not differ less than one minute nor more than fifteen.

The telescope being in the meridian, the foot-screws were adjusted so that the bubble of the zenith telescope level would play in both positions of the instrument, and being set at a mean zenith distance of the first pair of stars, the bubble of the level was brought to the middle of the tube and the level clamped, and as soon as the first star of the pair arrived on the middle transit thread it was bisected by the middle micrometer thread, and the time by chronometer noted. The micrometer and level readings were then taken and recorded and the instrument reversed. The second star of the pair was bisected on the middle transit thread with the same micrometer thread, the chronometer time of its culmination noted, and the micrometer and level read again. This constituted one observation for latitude. In all thirty-one pairs of stars were observed at this station.

The following notation was adopted: Let

φ=the latitude of the station;

δ_n and δ_s=the apparent declinations of the northern and southern stars;

ζ_n and ζ_s=the zenith distances of the northern and southern stars;

ζ_o=the zenith distance corresponding to the zero-reading of the micrometer;

M_n and M_s=the micrometer-readings for northern and southern stars expressed in revolutions of the micrometer;

m_n and m_s=the micrometer-readings for northern and southern stars expressed in seconds of arc;

m'_n and m'_s=the micrometer-readings for northern and southern stars expressed in minutes of arc;

L_n and L_s=the state of the level for northern and southern stars expressed in divisions of the level;

l_n and l_s=the state of the level for northern and southern stars expressed in seconds of arc; and

r_n and r_s=the value of the mean refraction for ζ_n and ζ_s.

In Talcott's method either of two cases may occur.

Case I. When the circle is east for the northern star and west for the southern star, the micrometer-reading increases as the zenith distance increases.

Case II. When the circle is east for the southern star and west for the northern star, the micrometer-reading increases as the zenith distance decreases.

Hence in Case I,

$$\zeta_n = \zeta_o + m_n + l_n + r_n$$
$$\zeta_s = \zeta_o + m_s + l_s + r_s$$
$$\zeta_n - \zeta_s = (m_n - m_s) + (l_n - l_s) + (r_n - r_s)$$

and in Case II,

$$\zeta_n = \zeta_o - m_n - l_n - r_n$$
$$\zeta_s = \zeta_o - m_s - l_s - r_s$$
$$\zeta_n - \zeta_s = -(m_n - m_s) - (l_n - l_s) - (r_n - r_s)$$

Since $\varphi = \delta_s + \zeta_s$ and also $\varphi = \delta_n - \zeta_n$, we have

$$\varphi = \tfrac{1}{2}(\delta_n + \delta_s) + \tfrac{1}{2}(\zeta_n - \zeta_s)$$

and in Case I,

$$\varphi = \tfrac{1}{2}(\delta_n + \delta_s) + \tfrac{1}{2}(m_n - m_s) + \tfrac{1}{2}(l_n - l_s) + \tfrac{1}{2}(r_n - r_s)$$

While in Case II,

$$\varphi = \tfrac{1}{2}(\delta_n + \delta_s) - \tfrac{1}{2}(m_n - m_s) - \tfrac{1}{2}(l_n - l_s) - \tfrac{1}{2}(r_n - r_s)$$

$$\tfrac{1}{2}(m_n - m_s) = \tfrac{1}{2}(M_n - M_s) \times 66''.93$$

Denoting the readings of the north and south ends of the bubble by N and S and N′ and S′, the inclinations observed at the time of the observations of the north and south stars, respectively, will be

$$L_n = \frac{N + S}{2} \text{ and } L_s = \frac{N' + S'}{2}$$

Hence,

$$\tfrac{1}{2}(l_n - l_s) = \frac{(N + S) - (N' + S')}{4} \times 1''.006$$

$$\tfrac{1}{2}(r_n - r_s) = \tfrac{1}{2}(m'_n - m'_s) \begin{cases} 0''.0167 \text{ for } \zeta = 0^\circ \\ 0''.0200 \text{ for } \zeta = 20^\circ \\ 0''.0225 \text{ for } \zeta = 30^\circ \end{cases}$$

These values for differential refraction were taken from Bessel's tables.

Date.	Catalogue No.	Magnitude.	Apparent declinations.	Half sum of declinations.	Corrections.			Latitude.	v.
					Micrometer.	Level.	Ref.		
1890.			° ′ ″	° ′ ″	′ ″	″	″	° ′ ″	
Jan. 17	178	5	32 45 16.36	26 43 26.42	—0 35.27	— 0.50	—0.02	26 42 50.63	0.25
	192	5	20 41 36.49						
	192	5	20 41 36.49	26 46 15.28	—3 23.47	— 0.50	—0.06	26 42 51.25	0.87
	195	5	32 50 54.07						
	199	6	19 23 29.28	26 47 59.27	—5 12.30	— 0.88	—0.09	26 42 46.00	4.38
	220	5	34 12 29.26						
	226	5	26 35 21.20	26 41 53.05	+1 00.71	— 1.51	+0.02	26 42 52.27	1.89
	243	4	26 48 24.91						
	269	6	24 49 35.33	26 44 30.41	—1 29.15	—12.42	—0.03	26 42 48.81	1.57
	275	6	28 39 25.50						
	269	6	24 49 35.33	26 44 16.62	—1 14.89	—12.93	—0.03	26 42 48.77	1.61
	292	5	28 38 57.91						
	313	5	10 57 25.50	26 35 40.02	+7 13.30	+ 1.00	+0.13	26 42 54.45	4.07
	337	4	42 13 54.55						
	362	4	35 28 30.24	26 40 43.98	+2 09.31	— 2.38	+0.03	26 42 50.91	0.53
	363	6	17 52 57.71						
	376	5	27 18 12.63	26 44 55.11	—1 59.60	— 2.13	—0.04	26 42 53.34	2.96
	384	6	26 11 37.59						
	407	5	34 18 04.23	26 37 06.83	+5 53.12	— 5.77	+0.09	26 42 54.27	3.89
	432	4	18 56 09.43						
	446	4	41 02 22.68	26 39 51.11	+3 07.54	— 4.77	+0.05	26 42 53.93	3.55
	453	4	12 17 19.54						
	501	5	15 14 59.08	26 48 07.84	—5 16.24	— 3.76	—0.10	26 42 47.74	2.64
	515	5	38 21 16.60						
18	178	5	32 45 16.36	26 43 26.43	—0 39.82	— 0.88	—0.02	26 42 45.70	4.68
	192	5	20 41 36.49						
	199	6	19 23 29.28	26 47 59.27	—5 12.16	— 0.63	—0.09	26 42 46.39	3.99
	220	5	34 12 29.26						
	407	5	34 18 04.23	26 37 06.83	+5 48.91	— 1.51	+0.09	26 42 54.32	3.94
	432	4	18 56 09.43						
	446	4	41 02 22.68	26 39 51.11	+3 06.53	— 3.39	+0.05	26 42 54.30	3.92
	453	4	12 17 19.54						
	501	5	15 14 59.08	26 48 07.84	—5 11.89	— 3.76	—0.01	26 42 51.18	0.80
	515	5	38 21 16.60						
	539	2	28 30 50.53	26 47 14.13	—4 26.38	— 0.88	—0.08	26 42 46.79	3.59
	546	6	25 03 37.74						
	555	6	14 13 35.90	26 41 05.30	+1 44.81	— 0.38	+0.03	26 42 49.76	0,62
	573	5	39 08 34.70						
	573	5	39 08 34.70	26 42 27.44	+0 25.83	— 4.14	+0.00	26 42 49.13	1.25
	581	6	16 16 20.19						
19	192	5	20 41 36.49	26 46 15.28	—3 25.54	+ 0.38	—0.05	26 42 50.07	0.31
	195	5	32 50 54.07						
	269	6	24 49 35.33	26 44 30.42	—1 37.52	— 3.39	—0.02	26 42 49.49	0.89
	275	6	28 39 25.50						
	313	5	10 57 25.50	26 35 40.02	+7 15.85	— 4.02	+0.11	26 42 51.96	1.58
	337	4	42 13 54.55						
	362	4	35 28 30.24	26 40 43.98	+2 05.96	— 0.13	+0.03	26 42 49.84	0.54
	363	6	17 52 57.71						
	376	5	27 18 12.63	26 44 55.11	—2 04.02	— 3.01	—0.03	26 42 48.05	2.33
	384	6	26 11 37.59						
	407	5	34 18 04.23	26 37 06.83	+5 49.98	— 5.40	—0.03	26 42 51.50	1.12
	432	4	18 56 09.43						
	446	4	41 02 22.68	26 39 51.11	+3 06.33	— 7.03	+0.05	26 42 50.46	0.08
	453	4	12 17 19.54						
	501	5	15 15 59.08	26 48 07.84	—5 10.49	—10.67	—0.08	26 42 46.60	3.78
	515	5	38 21 16.60						
	539	2	28 30 50.53	26 47 14.14	—4 13.80	— 5.40	—0.06	26 42 54.88	4.50
	546	6	25 03 37.74						
	555	6	14 13 35.90	26 41 05.30	+1 48.09	—13.89	+0.03	26 42 49.53	0.85
	573	5	39 08 34.70						
	630	3	22 34 09.28	26 33 52.40	+9 09.62	—13.43	+0.14	26 42 48.73	1.65
	633	5	30 33 35.53						

Mean $=26\ 42\ 50.38.$

$\Sigma v^2 = 221.469.$

Probable error of the arithmetical mean $= 0.6745 \sqrt{\frac{221.469}{30}}$

$= \pm 1''.83.$

CHAPTER VI.

THE MEASUREMENT OF ABREOJOS POINT BASE LINE.

The measurement was executed during January, 1890, by Lieut. U. R. Harris, assisted by Ensigns W. A. Gill and C. M. Knepper, U. S. Navy.

This base line is situated about 400 miles southward of San Diego on the generally level ground forming Abreojos Point. It begins near the extremity of the point and extends more than 2⅓ nautical miles, in a direction N. 6° 44′ E. (true), over even ground covered with sage-brush and consisting of sand with some coarse gravel and pebbles, underlaid in some places by stones and rocks covered by a foot or more of sand. There is a gradual descent from the southern end for about two-thirds of the distance, and then an ascent of about 3 feet per 100 for the remainder.

The measurement was made with a tape line of steel, one-eighth of an inch wide and 100 feet long, marked at intervals of 25 feet, and having composition handles at each end; four battens each 25 feet 6 inches long, with three sides, each side being 3 inches wide; twenty-four iron crutches to hold the battens firmly in place, having an angle of 60° to receive the battens, and varying in length from 2½ to 5 feet to admit of use upon uneven ground; a prismatic hand level; a spring balance; two plummets; a strong cord of about 120 feet in length; a number of small pegs for marking each 100 feet, and longer pegs for marking intervals of 1,000 feet; a theodolite and small poles with flags for use in aligning; hatchets, nails, paper, and pencils.

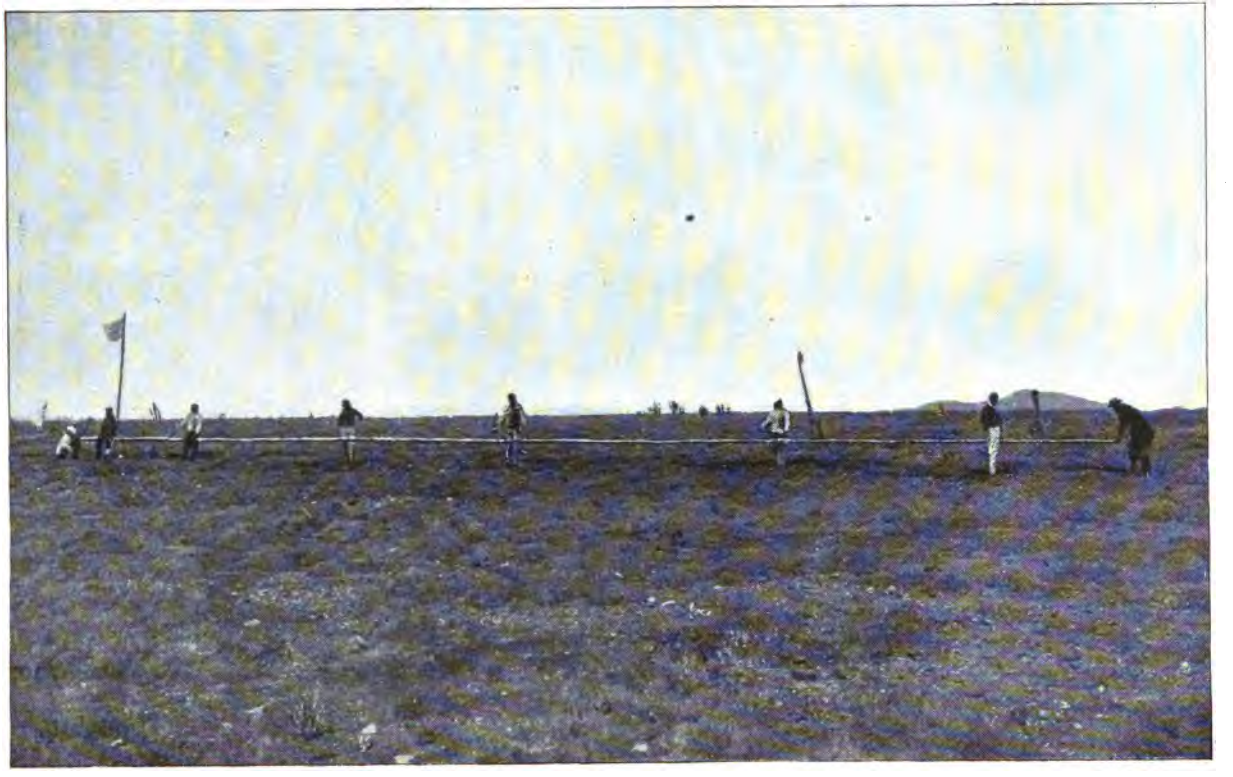
After determining upon the extremities of the base line, there were erected two tripod signals with the flagpoles vertically over the bases.

The ends of the base line were indicated by wooden stakes firmly driven into the ground, leaving an end above of about 15 inches, into which was driven a marked copper nail.

At the south base, in each leg of the tripod, about 18 inches from the ground, was driven a copper tack surrounded by iron nails, with the following distances to the nail in the stake: 9.25 feet for the south-eastern leg, 9.3 feet for the north leg, and 9.18 feet for the western leg.

The north end of the line is marked in the same manner, the distance to the south leg being 4.95 feet, northeast leg 7.75, and northwest leg 6.35 feet.

The measurement of the base line was begun about 3 p. m., January 13, after the completion of the tripod at the north base, when the alignment could be made to give the direction. The method of work was as follows: The officer at the theodolite first gives position to the flagman, whose pole will then be in the direction of the line; the cord is



MEASURING THE BASE LINE.

then tightly stretched along the ground. The officer at the theodolite shifts his position as often as necessary for convenience.

Alongside the stretched cord is placed an after crutch and a forward one, which are leveled by the officer at the after end of the line with the prismatic hand level. Next, the other crutches, making twelve in all, are placed and aligned by the officers at the forward and after ends; the battens for receiving the steel tape are then placed carefully, butting firmly.

This makes a firm and level path for the flat tape. Those stationed at the battens see that there are no turns and that it lies fair and straight.

The officer at the after end receives his end of the tape, and with plumb bob holds the zero mark over the copper tack of the peg in the ground, holding back against the strain put upon the other end.

At the forward end a strain of 20 pounds is put upon the line by hooking and hauling on the spring balance. This secures a uniform tension of the line throughout its length and insures its being straight on the battens. The officer at this end carefully plumbs the 100 foot mark to a peg driven into the ground. This peg will be to one side of the alignment by half of the width of the batten.

The forward peg being driven, the tally is made by the recorder and the officer at the after end, the flagman fleets along with his pole, dragging the cord, and the men at the battens throw them out to the left and take up the crutches. The advance is made about 4 feet from and parallel to the line, so as to keep clear of the view of the observer at the theodolite and not to disturb the pegs. The new position being reached, a halt is made and the former operation is repeated, clearing away bushes or other obstructions, if necessary.

At the end of each 1,000 feet a longer peg with a white flag is put alongside the peg. After completing the first day's work the party returned on board ship at 4:30 p. m. The weather during the time of measurement was clear and pleasant, with haze about the horizon and a fresh breeze from the northward and westward.

Work was resumed on the 14th, the party leaving the ship at 6:40 a. m. and returning on board at 5:25 p. m. The weather throughout the day was clear and pleasant, with calms and light variable airs—an excellent day for the work.

On January 15 a strong gale prevailed from the northeast, making a bad landing, with clouds of sand blowing and too much wind for steadying the plumb bob.

At 6:40 a. m., on the 16th, the base-line party landed and continued the work, reaching the north base signal at about 10 a. m., with a measurement expressed in units of the steel tape of 13,908.26 feet. A length of 8.26 feet was measured with a common tape line.

The first measurement being completed, the second was begun with an entirely independent system of alignment and pegs. Advantage was taken upon finishing each 1,000 feet to compare it with the nearest peg of the first system, thereby getting a comparison with each 1,000

feet. The weather during the day was clear and pleasant, with calms and light variable airs. In the afternoon there was a steady and gentle breeze from the westward. It was an excellent day for the work. On the 17th the party left the ship at 6:40 a. m. and returned upon completion of the measurement at 3:25 p. m. with all the apparatus. The result of the second measurement showed 13,908.08 feet in units of the steel tape. A length of 8.08 feet was measured by the common tape.

After verifying the alignment, a point on the line was selected where the transit instrument at the observation spot subtended 90° from either base, and the distance was measured to the center of the transit which was, in units of the line, 163 feet. The point on the base line was 1,519.72 feet from south base by the first measurement, and 1,519.58 feet by the second, expressed in units of the steel tape. The 17th was an excellent day for this work, the weather being clear and pleasant with light variable airs.

In order to arrive at the correct length of the 100 feet, as shown by the steel tape, reference was made by the standard yard furnished this vessel. Temperature was not considered, as no data were furnished in that respect. The steel tape was taken on shore and stretched along a corrider of the Coronado Hotel, Coronado Beach, California, with a strain of 20 pounds, under the conditions to which it was subjected in the field. There were marked upon the floor the 0, 25, 50, 75, and 100 feet intervals of the tape. With a beam compass a length of 35 inches was stepped off four times in succession, with the following results for the total distance:

Measuring from 0 foot to 100 feet gave 100 feet 0.66 inch.
Measuring from 100 feet to 0 foot gave 100 feet 0.65 inch.
Measuring from 0 foot to 100 feet gave 100 feet 0.68 inch.
Measuring from 100 feet to 0 foot gave 100 feet 0.70 inch.
Giving a mean of 100 feet 0.67 inch.

The distances for the subdivisions were found to be as follows:

0 foot to 25 feet to be 25 feet 0.29 inch.
0 foot to 50 feet to be 50 feet 0.36 inch.
0 foot to 75 feet to be 75 feet 0.50 inch.

The intermediate distances were determined by the mean of two measurements.

The common tape line was tested under the same circumstances as those under which it was used in the field and found to be correct for the distance measured with it.

The first measurement of the base was found to be, in units of the steel tape, 13,900 feet, plus 8.26 feet by the common tape. This, corrected, gives 13,916.02 feet. The second measurement shows 13,900 feet of the steel tape, plus 8.08 feet by the common tape, which, corrected, gives 13,915.84 feet. The adopted value of the length of the base line is the mean of the two results, 13,915.93 feet.

By the first measurement the distance from the south base to the point from which the perpendicular distance to the transit was meas-

ured is 1,500 feet, by the steel tape, plus 19.72 feet, by the common tape, from the south base, which, corrected, gives 1,520.56 feet.

By the second measurement the same distance is 1,500 feet, in units of the steel tape, plus the sum of two measurements by the common tape, of 8.08 feet and 11.50 feet. Correcting, we have 1,520.42 feet, with a mean corrected value of 1,520.79 feet.

The perpendicular distance to the center of the transit instrument, mounted on its pier, is 150 feet of the steel tape, plus 13 feet of the common tape, which, corrected, gives 163.09 feet.

The facility with which a base line can be measured commends this method. After the men had become accustomed to their duties upwards of 1,500 feet per hour were measured.

THE BEARING OF THE NORTH BASE FROM THE OBSERVATION SPOT.

The transit instrument was used for the determination of the azimuth of the base line. For the purpose of reference to the triangulation, a mark, made visible both by day and by night, was established at a distance of about 2 miles and as nearly in meridian as possible. Observations were taken of the micrometer measures of close circumpolar stars near culmination, and about the same time of the mark. The chronometer correction being known from the observations for time, the vertical thread of the micrometer was set in advance of the star by half turns of the screw and the transit recorded on the chronograph. The hour angle of each star was obtained by applying to the observed time the chronometer error, the right ascension of the star, and the corrections for level and collimation. The azimuth of the star was obtained from the formula $A = \frac{\sin p \sec(\varphi \pm p) \sin t}{\sin 1''} \pm$ for $\frac{\text{upper}}{\text{lower}}$ culmination, in which φ represents the latitude, p the polar distance, and t the hour angle. The difference between the micrometer-readings of the star and mark, converted into seconds of arc, being added algebraically to the azimuth of the star, gave a value for the azimuth of the mark. By combining the results deduced from the observations of separate stars the final result for the azimuth of the mark was obtained.

The angles between the mark and the different points of the triangulation, as measured by a theodolite, being applied to the azimuth of the mark will give the azimuths of the triangulation points. The position of the observatory is one of the points of the main triangulation.

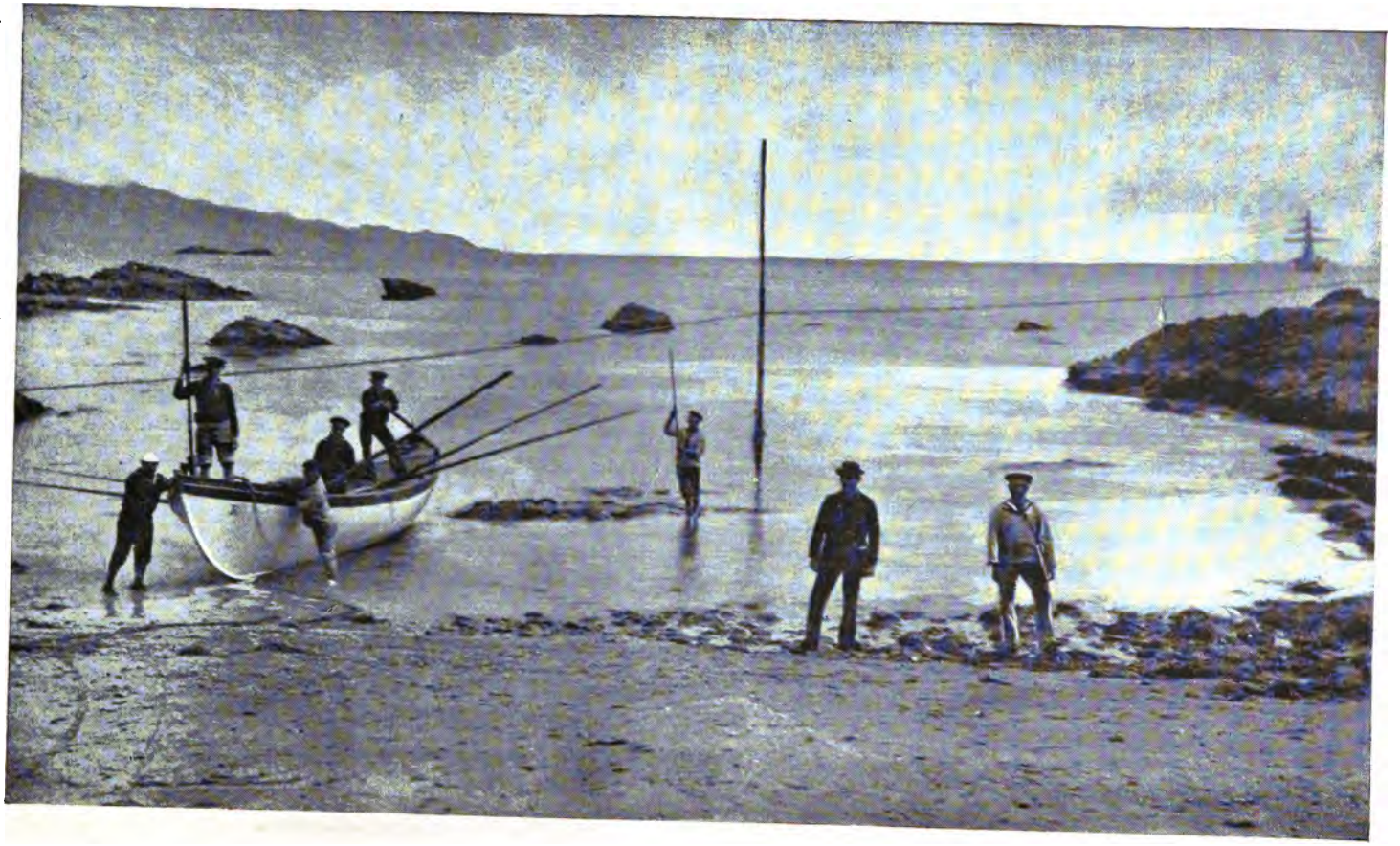
Date.	Name of star.	Azimuth of star.	Micrometer measure of angular distance between mark and star.	Azimuth of mark.
1891.		′ ″	′ ″	° ′ ″
Feb. 13	51 Cephei.....	N. 0 14.60 E.	0 4.21 E.	N. 0 00 18.81 E.
Feb. 14	δ Ursæ Minoris...	N. 3 25.23 E.	3 8.13 W.	N. 0 00 17.10 E.
Mean.....				N. 0 00 17.95 E.
Angular distance between the mark and the north base.....				N. 6 05 10.00 E.
Bearing of the north base from the observation spot.....				N. 6 05 27.95 E.

CHAPTER VII.

TIDAL OBSERVATIONS.

The tidal observations were made under the directions of Lieut. U. R. Harris, U. S. Navy, who made the computations and deduced the results.

The coast of Lower California from Port San Bartolomé to Abreojos Point afforded no protection for tidal observations other than such as could be obtained from jutting headlands, giving an anchorage to leeward of the prevailing coast winds. The landings were through surf, consequently it was necessary to erect the tide gauge behind Asuncion Island, outside of the surf and near some rocks, which gave sufficient depth with undisturbed water near the shore line. The form of gauge found to be the most serviceable in maintaining its position against the shocks of the sea was a pole about 15 feet in length and 3 inches in diameter. Close to the lower end were placed one or two sounding shot, held in place by a pin. The lower end was shod with a sharp iron pointer. At the upper end was an iron band with three eyes for reeving the laniards of the guys leading to three grapnels. To set up the gauge at the point selected the grapnels were placed with a view to the proper support of the staff. The pole was set in a vertical position, and the guys set up by means of the laniards, which should be above the high-water mark for convenience in readjusting the staff when it becomes necessary. The shot serve to anchor the pole and the iron point to secure it in its place in the ground or crevice of rock. The guys preserve the vertical direction. The staff, which consists of a board 4 inches wide and 1 inch thick, secured firmly upon the pole, is graduated to feet and tenths of a foot, and for convenience is made in two sections of 12 feet each. The face of the gauge was turned toward the shore in order that the observer might read it from the beach, using a spyglass when necessary. At night a small boat was used to go alongside to read the height of the water. Experience showed that this gauge was readily planted and adjusted, and quickly restored if displaced by stress of weather. In order to verify the permanency of the gauge, the observer was instructed to note the lines of the covering and uncovering of some conspicuous object, as a rock. The agreement of the lines to a constant height verifies its stability or gives the new relation to the reference plane. The bench mark is a permanent mark made upon a natural or artificial object, to record the height above the plane of reference. It is established by a line of levels, or it may be



A TIDAL STATION.

approximately determined when a sea horizon is available by sighting by the staff to the sea horizon, the eye being at the bench mark. The reading of the staff at its intersection with the line of the horizon should be recorded. It is preferable to have several bench marks, as a single one may be destroyed or obliterated. Use such locations for these marks as will insure permanency. If cutting in rock, make the cut deep enough to be recognized after an interval of years, and surround it by such marks as to render its identification undoubted. In describing bench marks use definite terms; do not assume that "a short distance," "a few yards," or "very near" is readily determinable. Instead of these indefinite terms use meters, yards, feet, inches, miles, or whatever measure of length is necessary to represent the distance. Make descriptions so full that anyone seeking a bench mark in after years can go to it at once. A sketch of the locality, noting the position of the bench or benches and giving the names of such objects as are likely to retain their existing form is desirable. For convenience, when no permanent bench is near where the gauge is to be set up, establish a temporary bench, such as a row of nails driven in a pile. Make a record of the height of this bench mark on the gauge, as well as that of the permanent bench.

It is essential in selecting a station for tidal observations to have it clear of local disturbances of the sea level by reason of swash over rocks, or from any peculiarity of the surroundings.

A self-registering gauge is very valuable, but it can not be placed outside of the ship in exposed positions. As the advantages of mechanical and continuous records of the whole tide are in favor of accuracy and facility for computation, it should be employed when the instrument can be protected. The location of the principal tide gauge should be determined with reference to its value in showing the establishment of the port of some important point or part of the coast, at the same time serving the interests of the immediate work in hand. The station should be central, so that too much time should not be lost in keeping the observers supplied with water and provisions. The tidal party landed from the *Ranger*, consisting of a reliable petty officer who was a good seaman, ready in resources to make needed adjustments and repairs to the gauge, and one who could make the party comfortable. He had two assistants, and a small dory was provided for reading the gauge at night. Observations were made every fifteen minutes throughout the day and night, and continued as nearly to a period of six weeks as possible. It was not deemed advisable to leave a party on shore while the ship went to San Diego for coal, since there was no fresh water and scarcely any animal or vegetable life along the coast. Secondary gauges of smaller form were used to correct soundings whenever any harbor or roadstead work was done. They were connected with the principal one by means of the high and low waters.

In selecting the place for the erection of a secondary tide gauge make sure that it is exposed to the same influences of wind and tide as

the area over which it is to furnish the tidal reduction. A gauge must be subject to the same influences both as to *force* and *time* as the area over which soundings are taken or it is worthless or perhaps misleading. If necessary, a gauge must be built in the open, even if knocked down and rebuilt every day. A series of all-day comparisons with a gauge in a more sheltered situation where the observations are continuous will be sufficient to determine the range and plane of reference. In computing the tidal reduction undue minuteness is a mistake. The reduced sounding should be computed to within one-half the assumed error of the sounding. Thus, if soundings are taken to the nearest foot, the reduction need not be closer than half a foot. Reduction to tenths of a foot under such circumstances is misleading, because it gives an appearance of accuracy which does not exist.

Readings of the gauges were taken every fifteen minutes throughout the period during which soundings were made. The reference plane selected was that corresponding to the mean of the three lowest low waters observed. The observations were plotted on specially ruled paper, using the time intervals as abscissæ and the corresponding heights of the water as ordinates. From the sinusoidal curves thus produced interruptions in the observations of less than a day in extent can be reliably allowed for from the data resulting from the survey, and imperfect observations may be corrected by comparing the curves resulting from them with those relating to the days on which they are similar and complete. The establishment of the port was determined by taking the mean of all the luni-tidal intervals observed during a period of four weeks.

Observations of tidal currents were made when opportunities presented themselves by anchoring boat in the channels within the influence of the currents, and observing the direction and strength at the surface.

Results of tidal observations.

	Abreojos Point.	Asuncion Bay.
H. W. F. & C	9 h. 02.8 m.	9 h. 01.8 m.
L. W. F. & C	15 h. 26.9 m.	15 h. 20.3 m.
Plane of reference to which soundings are reduced, being the mean of the three lowest low waters observed	0. 80 ft.	2. 10 ft.
Reading of the bench mark on tide staff	7. 40 ft.	11. 40 ft.
Highest high water observed	9. 50 ft.	10. 60 ft.
Lowest high water observed	4. 95 ft.	6. 20 ft.
Highest low water observed	4. 40 ft.	6. 20 ft.
Lowest low water observed	0. 70 ft.	2. 10 ft.
Mean height of high water	7. 72 ft.	8. 40 ft.
Mean height of low water	2. 68 ft.	4. 15 ft.
Mean rise and fall of tide	4. 59 ft.	4. 25 ft.
Greatest rise and fall of tide	8. 80 ft.	
Least rise and fall of tide	0. 55 ft.	
Mean length of flood tide (from low water to high water)	6 h. 06.3 m.	
Mean length of flood ebb tide (from high water to low water)	6 h. 23.9 m.	

TIDAL OBSERVERS' CAMP.

Specimen page.

[Observations of tides at Asuncion Bay, Lower California. Year: 1890. Month: February. Day of month: 18th.]

Mean time of observation.		Reading of tide staff.		Wind.		Barometer.		Thermometer.				Atmosphere.	Clouds.				Weather.	Patent gauge.
Hours.	Minutes.	Feet.	Decimals.	Direction.	Force.	Inches.	Decimals.	Attached.	Air.	Water.	Wet bulb.		Sky covered in 8ths.	Kind.	Course of— Upper.	Course of— Lower.		
P. M.																		*Ft. In.*
12	00	3	9	....	3	....	....	....	....	....	....	....	....	....	....	....	Cloudy.	2-4
	15	3	6	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	2-1
	30	3	4	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	1-9
	45	3	2	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	1-7
1	00	2	9	....	3	....	....	....	....	....	....	....	.....	....	....	....	...do	1-4
	15	2	6	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	1-1
	30	2	3	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	-8
	45	2	2	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	-7
2	00	2	2	....	3-2	....	....	....	....	....	....	....	.....	....	....	....	...do	-7
	15	2	1.5	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	-6
	30	2	1	Low tide		....	....	....	....	....	....	....	.....	Low water			...do	-6
	45	2	1			....	....	....	....	....	....	....	.....				...do	-6
3	00	2	2	....	2	....	....	....	....	....	....	....	.....	....	....	....	...do	-6
	15	2	4	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	1-0
	30	2	7	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	1-2
	45	3	3	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	1-5
4	00	3	7	....	2	....	....	....	....	....	....	....	.....	....	....	....	...do	1-9
	15	4	0	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	2-1
	30	4	4	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	2-4
	45	4	7	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	2-7
5	00	5	1	....	1-2	....	....	....	....	....	....	....	.....	....	....	....	...do	3-2
	15	5	6	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	3-7
	30	5	9	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	4-0
	45	6	2	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	4-3
6	00	6	6	....	2	....	....	....	....	....	....	....	.....	....	....	....	...do	4-7
	15	6	8	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	4-9
	30	7	0	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	5-1
	45	7	2.5	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	5-3.2
7	00	7	5	....	1-2	....	....	....	....	....	....	....	.....	....	....	....	...do	5-6
	15	7	7	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	5-7.2
	30	7	8	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	5-9
	45	7	9	High tide		....	....	....	....	....	....	....	.....	....	....	....	...do	6-0
8	00	7	9	2		....	....	....	....	....	....	....	.....	....	....	....	...do	6-0
	15	7	9			....	....	....	....	....	....	....	.....	....	....	....	...do	6-0
	30	7	8	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	5-9
	45	7	7	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	5-8
9	00	7	6	....	2	....	....	....	....	....	....	....	.....	....	....	....	...do	5-7
	15	7	5.5	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	5-6
	30	7	5	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	5-6
	45	7	3	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	5-4
10	00	7	1	....	2	....	....	....	....	....	....	....	.....	....	....	....	...do	5-2
	15	6	9	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	5-0
	30	6	7	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	4-8
	45	6	6	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	4-7
11	00	6	5	....	2-1	....	....	....	....	....	....	....	.....	....	....	....	...do	4-6
	15	6	1	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	4-2
	30	5	7	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	3-6
	45	5	4	....	.....	....	....	....	....	....	....	....	.....	....	....	....	...do	3-2

CHAPTER VIII.

CONSTRUCTING THE CHARTS.

The observations referred to in the foregoing chapters having been completed, and recorded and plotted according to the methods described, the data are transmitted to the Hydrographic Office, Navy Department, to be used in the construction of nautical charts. Here a polyconic projection is constructed, on a natural scale of $\frac{1}{126720}$. The following table has been arranged for this purpose as it possesses an advantage over the tables in ordinary use, since they require that the ordinates and abscissæ shall be multiplied by a coefficient depending upon the scale, while in this case they are taken directly from the table:

Latitude of parallel.	Meridional distances from even degree parallels.	Coördinates of developed parallel for—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
° ′	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
0 00	.....	8.646	0.000	17.293	0.000	25.939	0.000	34.585	0.000
15	8.588	8.646	.000	17.292	.000	25.939	.001	34.585	.001
30	17.175	8.646	.000	17.292	.001	25.937	.001	34.584	.002
45	25.763	8.645	.000	17.291	.001	25.936	.002	34.582	.003
1 00	34.351	8.645	.000	17.290	.001	25.935	.003	34.580	.005
15	8.588	8.644	.000	17.289	.002	25.933	.004	34.577	.006
30	17.176	8.643	.000	17.287	.002	25.930	.004	34.573	.007
45	25.764	8.642	.001	17.285	.002	25.928	.005	34.569	.009
2 00	34.352	8.641	.001	17.282	.003	25.924	.006	34.564	.010
15	8.588	8.640	.001	17.280	.003	25.919	.007	34.559	.012
30	17.176	8.639	.001	17.279	.003	25.915	.007	34.553	.013
45	25.764	8.637	.001	17.273	.004	25.909	.008	34.546	.014
3 00	34.352	8.634	.001	17.269	.004	25.904	.009	34.538	.015
15	8.588	8.632	.001	17.265	.004	25.898	.010	34.530	.017
30	17.176	8.630	.001	17.261	.004	25.891	.010	34.521	.018
45	25.764	8.628	.001	17.256	.005	25.884	.011	34.512	.019
4 00	34.352	8.625	.001	17.251	.005	25.876	.012	34.502	.021
15	8.588	8.623	.001	17.245	.005	25.868	.013	34.492	.022
30	17.176	8.620	.001	17.240	.006	25.860	.013	34.480	.023
45	25.764	8.617	.002	17.234	.006	25.851	.014	34.468	.025
5 00	34.352	8.614	.002	17.227	.006	25.841	.015	34.455	.026
15	8.588	8.610	.002	17.221	.007	25.831	.015	34.442	.027
30	17.177	8.607	.002	17.214	.007	25.820	.016	34.428	.028
45	25.765	8.603	.002	17.206	.007	25.809	.017	34.413	.030
6 00	34.354	8.599	.002	17.198	.008	25.797	.018	34.397	.031
15	8.589	8.595	.002	17.190	.008	25.786	.018	34.381	.032
30	17.177	8.591	.002	17.183	.008	25.774	.019	34.365	.034
45	25.766	8.587	.002	17.174	.009	25.761	.020	34.348	.035

Latitude of parallel.	Meridional distances from even degree parallels.	Coördinates of developed parallel for—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
° ′	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
7 00	34.355	8.582	.002	17.165	.009	25.747	.020	34.330	.036
15	8.589	8.577	.002	17.155	.009	25.733	.021	34.311	.037
30	17.178	8.573	.002	17.146	.010	25.719	.022	34.292	.039
45	25.767	8.567	.002	17.135	.010	25.704	.023	34.271	.040
8 00	34.356	8.562	.003	17.125	.010	25.688	.023	34.251	.041
15	8.590	8.557	.003	17.115	.011	25.672	.024	34.230	.042
30	17.179	8.552	.003	17.104	.011	25.656	.025	34.208	.044
45	25.769	8.546	.003	17.093	.011	25.639	.025	34.186	.045
9 00	34.358	8.540	.003	17.081	.012	25.622	.026	34.162	.046
15	8.590	8.535	.003	17.069	.012	25.604	.027	34.139	.047
30	17.180	8.528	.003	17.057	.012	25.585	.028	34.114	.049
45	25.770	8.522	.003	17.045	.013	25.567	.028	34.089	.050
10 00	34.360	8.516	.003	17.032	.013	25.547	.029	34.064	.051
15	8.591	8.509	.003	17.018	.013	25.527	.030	34.037	.052
30	17.181	8.502	.003	17.005	.014	25.507	.030	34.010	.054
45	25.771	8.496	.003	16.992	.014	25.487	.031	33.983	.055
11 00	34.362	8.488	.003	16.976	.014	25.466	.032	33.955	.056
15	8.591	8.481	.004	16.962	.014	25.443	.032	33.925	.057
30	17.182	8.474	.004	16.948	.015	25.421	.033	33.895	.059
45	25.773	8.466	.004	17.932	.015	25.399	.034	33.864	.060
12 00	34.364	8.458	.004	16.917	.015	25.376	.034	33.835	.061
15	8.592	8.451	.004	16.902	.016	25.352	.035	33.803	.062
30	17.183	8.443	.004	16.886	.016	25.328	.036	33.771	.063
45	25.775	8.435	.004	16.869	.016	25.304	.036	33.738	.064
13 00	34.367	8.426	.004	16.852	.016	25.278	.037	33.705	.066
15	8.592	8.417	.004	16.835	.017	25.253	.038	33.671	.067
30	17.185	8.409	.004	16.818	.017	25.227	.038	33.636	.068
45	25.777	8.400	.004	16.800	.017	25.200	.039	33.601	.069
14 00	34.369	8.391	.004	16.782	.018	25.173	.040	33.564	.070
15	8.593	8.382	.004	16.764	.018	25.146	.040	33.528	.072
30	17.186	8.373	.005	16.746	.018	25.118	.041	33.491	.073
45	25.779	8.363	.005	16.727	.019	25.090	.042	33.453	.074
15 00	34.372	8.354	.005	16.707	.019	25.061	.042	33.414	.075
15	8.594	8.344	.005	16.688	.019	25.032	.043	33.375	.076
30	17.187	8.334	.005	16.668	.020	25.002	.044	33.335	.078
45	25.781	8.324	.005	16.648	.020	24.971	.044	33.295	.079
16 00	34.374	8.313	.005	16.627	.020	24.940	.045	33.254	.080
15	8.594	8.303	.005	16.606	.020	24.909	.046	33.212	.081
30	17.188	8.292	.005	16.585	.020	24.877	.046	33.170	.082
45	25.783	8.282	.005	16.564	.021	24.845	.047	83.128	.083
17 00	34.377	8.271	.005	16.542	.021	24.813	.047	33.084	.084
15	8.595	8.260	.005	16.519	.021	24.779	.048	33.039	.085
30	17.190	8.249	.005	16.498	.022	24.746	.049	32.995	.086
45	25.785	8.237	.005	16.475	.022	24.712	.049	32.949	.088
18 00	34.380	8.226	.005	16.452	.022	24.678	.050	32.904	.089
15	8.596	8.214	.006	16.428	.022	24.643	.050	32.857	.090
30	17.192	8.202	.006	16.405	.023	24.607	.051	32.810	.091
45	25.788	8.190	.006	16.381	.023	24.571	.052	32.762	.092
19 00	34.384	8.178	.006	16.356	.023	24.534	.052	32.713	.093
15	8.597	8.166	.006	16.332	.023	24.498	.053	32.664	.094
30	17.194	8.153	.006	16.307	.024	24.460	.053	32.615	.095
45	25.791	8.141	.006	16.282	.024	24.423	.054	32.563	.096

Latitude of parallel.		Meridional distances from even degree parallels.	Coördinates of developed parallels for—							
			15′ longitude.		30′ longitude.		45 longitude.		1° longitude.	
			x	y	x	y	x	y	x	y
°	′	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
20	00	34.388	8.128	.006	16.257	.024	24.385	.054	32.513	.097
	15	8.598	8.115	.006	16.230	.024	24.346	.055	32.461	.098
	30	17.196	8.102	.006	16.205	.025	24.307	.056	32.409	.099
	45	25.794	8.089	.006	16.178	.025	24.267	.056	32.356	.100
21	00	34.392	8.076	.006	16.152	.025	24.227	.057	32.303	.101
	15	8.599	8.062	.006	16.124	.025	24.186	.057	32.248	.102
	30	17.198	8.048	.006	16.097	.026	24.145	.058	32.194	.103
	45	25.797	8.035	.006	16.069	.026	24.104	.058	32.138	.104
22	00	34.396	8.021	.007	16.041	.026	24.062	.059	32.083	.105
	15	8.600	8.006	.007	16.013	.026	24.020	.059	32.026	.106
	30	17.200	7.992	.007	15.984	.027	23.976	.060	31.969	.107
	45	25.800	7.978	.007	15.956	.027	23.934	.060	31.912	.107
23	00	34.400	7.963	.007	10.926	.027	23.889	.061	31.852	.109
	15	8.601	7.948	.007	15.897	.027	23.845	.061	31.794	.109
	30	17.202	7.933	.007	15.867	.028	23.800	.062	31.734	.110
	45	25.803	7.918	.007	15.837	.028	23.755	.062	31.674	.111
24	00	34.404	7.903	.007	15.806	.028	23.709	.063	31.613	.112
	15	8.602	7.888	.007	15.776	.028	23.664	.063	31.552	.113
	30	17.205	7.872	.007	15.744	.028	23.616	.064	31.488	.114
	45	25.807	7.856	.007	15.713	.029	23.569	.064	31.426	.115
25	00	34.409	7.841	.007	15.682	.029	23.523	.065	31.364	.116
	15	8.604	7.825	.007	15.650	.029	23.475	.065	31.300	.117
	30	17.207	7.809	.007	15.617	.029	23.426	.066	31.235	.117
	45	25.811	7.793	.007	15.585	.029	23.378	.067	31.170	.118
26	00	34.415	7.776	.007	15.553	.030	23.329	.067	31.106	.119
	15	8.605	7.760	.007	15.519	.030	23.279	.067	31.039	.120
	30	17.210	7.743	.007	15.486	.030	23.229	.068	30.972	.121
	45	25.814	7.726	.008	15.452	.030	23.179	.068	30.905	.121
27	00	34.419	7.709	.008	15.419	.031	23.128	.069	30.838	.122
	15	8.606	7.692	.008	15.384	.031	23.076	.069	30.769	.123
	30	17.212	7.675	.008	15.350	.031	23.024	.070	30.699	.124
	45	25.818	7.657	.008	15.315	.031	22.972	.070	30.630	.124
28	00	34.424	7.640	.008	15.280	.031	22.920	.070	30.560	.125
	15	8.607	7.622	.008	15.244	.031	22.866	.071	30.489	.126
	30	17.215	7.604	.008	15.208	.032	22.813	.071	30.417	.127
	45	25.822	7.586	.008	15.173	.032	22.759	.072	30.345	.127
29	00	34.430	7.668	.008	15.137	.032	22.705	.072	30.274	.128
	15	8.609	7.550	.008	15.100	.032	22.650	.072	30.200	.129
	30	17.217	7.531	.008	15.063	.032	22.594	.073	30.125	.130
	45	25.826	7.513	.008	15.026	.033	22.539	.073	30.051	.130
30	00	34.435	7.494	.008	14.989	.033	22.483	.074	29.978	.131
	15	8.610	7.475	.008	14.951	.033	22.426	.074	29.902	.131
	30	17.220	7.456	.008	14.913	.033	22.369	.074	29.825	.132
	45	25.830	7.437	.008	14.874	.033	22.312	.075	29.749	.133
31	00	34.440	7.418	.008	14.836	.033	22.254	.075	29.672	.133
	15	8.611	7.398	.008	14.797	.033	22.195	.075	29.594	.134
	30	17.223	7.379	.008	14.758	.034	22.137	.076	29.515	.135
	45	25.834	7.359	.008	14.718	.034	22.078	.076	29.437	.135
32	00	34.446	7.340	.008	14.679	.034	22.019	.076	29.358	.136
	15	8.613	7.319	.008	14.639	.034	21.958	.077	29.278	.136
	30	17.225	7.299	.009	14.598	.034	21.898	.077	29.197	.137
	45	25.838	7.279	.009	14.558	.034	21.837	.077	29.116	.137

Latitude of parallel.		Meridional distances from even degree parallels.	Coördinates of developed parallel for—							
			15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
			x	y	x	y	x	y	x	y
°	′	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
33	00	34.451	7.259	.009	14.518	.034	21.777	.078	29.036	.138
	15	8.614	7.238	.009	14.476	.035	21.714	.078	28.953	.138
	30	17.228	7.217	.009	14.435	.035	21.652	.078	28.953	.138
	45	25.842	7.197	.009	14.393	.035	21.590	.078	28.869	.139
34	00	34.456	7.176	.009	14.352	.035	21.527	.079	28.703	.140
	15	8.615	7.154	.009	14.309	.035	21.464	.079	28.618	.141
	30	17.231	7.133	.009	14.266	.035	21.400	.079	28.533	.141
	45	25.846	7.112	.009	14.224	.035	21.336	.080	28.448	.142
35	00	34.462	7.091	.009	14.181	.035	21.272	.080	28.362	.142
	15	8.617	7.069	.009	14.138	.036	21.207	.080	28.275	.142
	30	17.234	7.047	.009	14.094	.036	21.141	.080	28.188	.143
	45	25.851	7.025	.009	14.050	.036	21.076	.080	28.101	.143
36	00	34.468	7.003	.009	14.007	.036	21.010	.081	28.014	.144
	15	8.618	6.981	.009	13.962	.036	20.943	.081	27.924	.144
	30	17.237	6.959	.009	13.917	.036	20.876	.081	27.835	.144
	45	25.855	6.936	.009	13.873	.036	20.809	.081	27.745	.145
37	00	34.474	6.914	.009	13.828	.036	20.742	.082	27.655	.145
	15	8.620	6.891	.009	13.782	.036	30.673	.082	27.564	.145
	30	17.240	6.068	.009	13.736	.036	30.604	.082	27.472	.146
	45	25.860	6.845	.009	13.690	.037	20.536	.082	27.381	.146
38	00	34.480	6.822	.009	13.645	.037	20.467	.082	27.289	.147
	15	8.621	6.799	.009	13.598	.037	20.397	.083	27.196	.147
	30	17.243	6.775	.009	13.551	.037	20.326	.083	27.102	.147
	45	25.864	6.752	.009	13.504	.037	20.256	.083	27.008	.147
39	00	34.485	6.729	.009	13.457	.037	20.186	.083	26.914	.148
	15	8.623	6.705	.009	13.409	.037	20.114	.083	26.819	.148
	30	17.246	6.681	.009	13.361	.037	20.042	.083	26.723	.148
	45	25.868	6.657	.009	13.314	.037	19.970	.084	26.627	.148
40	00	34.491	6.633	.009	13.266	.037	19.899	.084	26.532	.149
	15	8.624	6.608	.009	13.217	.037	19.825	.084	26.434	.149
	30	17.249	6.584	.009	13.168	.037	19.752	.084	26.336	.149
	45	25.873	6.560	.009	13.119	.037	19.679	.084	26.238	.149
41	00	34.497	6.535	.009	13.070	.037	19.605	.084	16.140	.150
	15	8.625	6.510	.009	13.020	.037	19.530	.084	26.041	.150
	30	17.250	6.485	.909	12.970	.037	19.456	.084	25.941	.150
	45	25.875	6.460	.009	12.920	.037	19.381	.084	25.841	.150
42	00	34.500	6.435	.009	12.871	.037	19.306	.085	25.741	.150
	15	8.627	6.410	.009	12.820	.037	19.230	.085	25.640	.150
	30	17.255	6.385	.009	12.769	.038	19.154	.085	25.538	.151
	45	25.882	6.359	.009	12.718	.038	19.077	.085	25.436	.151
43	00	34.510	6.334	.009	12.667	.038	19.001	.085	25.335	.151
	15	8.629	6.308	.009	12.615	.038	18.923	.085	25.231	.151
	30	17.257	6.282	.009	12.563	.038	18.845	.085	25.127	.151
	45	25.886	6.256	.009	12.512	.038	18.767	.085	25.023	.151
44	00	34.515	6.230	.009	12.460	.038	18.689	.085	24.919	.151
	15	8.630	6.203	.009	12.407	.038	18.610	.085	14.814	.151
	30	17.261	6.177	.009	12.354	.038	18.531	.085	24.708	.151
	45	25.891	6.151	.009	12.301	.038	18.452	.085	24.603	.151
45	00	34.522	6.124	.009	12.249	.038	18.373	.085	23.497	.151
	15	8.632	6.097	.009	12.195	.038	18.292	.085	24.390	.151
	30	17.264	6.071	.009	12.141	.038	18.212	.085	24.283	.151
	45	25.896	6.044	.009	12.088	.038	18.131	.085	24.175	.151

Latitude of parallel.	Meridional distances from even degree parallels.	Coördinates of developed parallel for—							
		15′ longitude.		30′ longitude.		45′ longitude.		1° longitude.	
		x	y	x	y	x	y	x	y
° ′	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
46 00	34.528	6.017	.009	12.034	.038	18.051	.085	24.068	.151
15	8.633	5.990	.009	11.979	.038	17.969	.085	23.959	.151
30	17.267	5.962	.009	11.825	.038	17.887	.085	23.849	.151
45	25.901	5.935	.009	11.870	.038	17.805	.085	23.740	.151
47 00	34.534	5.908	.009	11.815	.038	17.723	.085	23.631	.151
15	8.635	5.880	.009	11.760	.038	17.640	.085	23.520	.151
30	17.270	5.852	.009	11.704	.038	17.556	.085	23.408	.151
45	25.905	5.824	.009	11.648	.038	17.473	.085	23.297	.151
48 00	34.540	5.796	.009	11.593	.038	17.389	.085	13.186	.150
15	8.637	5.768	.009	11.536	.038	17.305	.085	23.073	.150
30	17.273	5.740	.009	11.480	.038	17.220	.084	22.960	.150
45	25.910	5.712	.009	11.424	.037	17.135	.084	22.847	.150
49 00	34.546	5.684	.009	11.367	.037	17.051	.084	22.734	.150
15	8.638	5.655	.009	11.310	.037	16.965	.084	22.620	.150
30	17.276	5.626	.009	11.253	.037	16.879	.084	22.505	.150
45	25.914	5.598	.009	11.195	.037	16.793	.084	22.391	.150
50 00	34.552	5.569	.009	11.138	.037	16.707	.084	22.276	.150
15	8.639	5.540	.009	11.080	.037	16.620	.084	22.160	.149
30	17.278	5.511	.009	11.022	.037	16.533	.083	22.044	.148
45	25.917	5.482	.009	10.963	.037	16.445	.083	21.926	.148
51 00	34.556	5.452	.009	10.905	.037	16.357	.082	21.810	.148
15	8.641	5.423	.009	10.846	.037	16.269	.082	21.692	.147
30	17.282	5.394	.009	10.787	.037	16.181	.082	21.574	.147
45	25.923	5.364	.009	10.728	.037	16.092	.082	21.457	.147
52 00	34.564	5.334	.009	10.669	.037	16.003	.082	21.338	.147
15	8.643	5.305	.009	10.609	.037	15.914	.082	21.219	.146
30	17.286	5.275	.009	10.550	.036	15.825	.082	21.100	.146
45	25.929	5.245	.009	10.489	.036	15.734	.082	20.979	.146
53 00	34.572	5.215	.009	10.429	.036	15.644	.082	20.859	.145
15	8.644	5.185	.009	10.369	.036	15.554	.081	20.739	.145
30	17.288	5.154	.009	10.308	.036	15.463	.081	20.617	.145
45	25.932	5.124	.009	10.248	.036	15.372	.081	20.496	.144
54 00	34.576	5.093	.009	10.187	.036	15.279	.081	20.374	.144
15	8.645	5.063	.009	10.126	.036	15.189	.081	20.252	.143
30	17.290	5.032	.009	10.064	.036	15.096	.080	20.129	.143
45	25.935	5.002	.009	10.003	.036	15.004	.080	20.006	.143
55 00	34.580	4.971	.009	9.941	.035	14.912	.080	19.882	.142
15	8.647	4.940	.009	9.879	.035	14.819	.080	19.758	.142
30	17.294	4.909	.009	9.817	.035	14.726	.079	19.635	.141
45	25.941	4.878	.009	9.755	.035	14.633	.079	19.510	.141
56 00	34.588	4.846	.009	9.692	.035	14.539	.079	19.385	.140
15	8.648	4.815	.009	9.630	.035	14.445	.079	19.260	.140
30	17.296	4.784	.009	9.567	.035	14.351	.078	19.134	.139
45	25.944	4.752	.009	9.504	.035	14.256	.078	19.008	.139
57 00	34.592	4.720	.009	9.441	.034	14.161	.078	18.882	.138
15	8.650	4.689	.009	9.377	.034	14.066	.077	18.755	.138
30	17.300	4.657	.009	9.314	.034	13.971	.077	18.628	.137
45	25.950	4.625	.008	9.250	.034	13.875	.077	18.500	.136
58 00	34.600	4.593	.008	9.186	.034	13.779	.076	18.372	.136
15	8.651	4.561	.008	9.122	.034	13.683	.076	18.244	.135
30	17.302	4.529	.008	9.058	.034	13.587	.076	18.116	.135
45	25.953	4.497	.008	8.993	.033	13.490	.075	17.986	.134

Latitude of parallel.		Meridional distances from even degree parallels.	Coördinates of developed parallel for—							
			15′ longitude.		30 longitude.		45′ longitude.		1° longitude.	
			x	y	x	y	x	y	x	y
°	′	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
59	00	34.604	4.464	.008	8.929	.033	13.393	.075	17.857	.134
	15	8.652	4.432	.008	8.864	.033	13.296	.075	17.728	.133
	30	17.304	4.399	.008	8.799	.033	13.198	.074	17.598	.132
	45	25.956	4.367	.008	8.734	.033	13.201	.074	17.468	.132
60	00	34.608	4.334	.008	8.668	.033	13.003	.074	17.337	.131
	15	8.654	4.301	.008	8.603	.033	12.904	.073	17.206	.130
	30	17.308	4.269	.008	8.537	.032	12.806	.073	17.074	.130
	45	25.962	4.236	.008	8.471	.032	12.707	.072	16.942	.129
61	00	34.616	4.203	.008	8.405	.032	12.608	.072	16.811	.128
	15	8.655	4.170	.008	8.339	.032	12.508	.072	16.678	.127
	30	17.310	4.136	.008	8.273	.032	12.409	.071	16.546	.127
	45	25.965	4.103	.008	8.206	.031	12.309	.071	16.413	.126
62	00	34.620	4.070	.008	8.140	.031	12.210	.070	16.280	.125
	15	8.656	4.037	.008	8.073	.031	12.109	.070	16.146	.125
	30	17.312	4.003	.008	8.006	.031	12.009	.070	16.012	.124
	45	25.968	3.970	.008	7.939	.031	11.908	.069	15.878	.123
63	00	34.624	3.936	.008	7.872	.031	11.808	.069	15.744	.122
	15	8.658	3.902	.008	7.804	.030	11.707	.068	15.609	.122
	30	17.316	3.868	.007	7.737	.030	11.605	.068	15.474	.121
	45	25.974	3.835	.007	7.669	.030	11.504	.067	15.338	.120
64	00	34.632	3.801	.007	7.601	.030	11.402	.067	15.202	.119
	15	8.659	3.767	.007	7.533	.030	11.300	.067	15.067	.118
	30	17.318	3.733	.007	7.465	.029	11.198	.066	14.930	.118
	45	25.977	3.699	.007	7.397	.029	11.095	.066	14.794	.117
65	00	34.636	3.664	.007	7.328	.029	10.993	.065	14.657	.116
	15	8.660	3.630	.007	7.260	.029	10.890	.065	14.520	.115
	30	17.320	3.596	.007	7.191	.028	10.787	.064	14.382	.114
	45	25.980	3.561	.007	7.122	.028	10.683	.064	14.245	.113
66	00	34.640	3.527	.007	7.053	.028	10.580	.063	14.107	.112
	15	8.661	3.492	.007	6.984	.028	10.477	.063	13.969	.111
	30	17.322	3.458	.007	6.915	.028	10.373	.062	13.830	.110
	45	25.983	3.423	.007	6.845	.027	10.268	.062	13.691	.110
67	00	34.644	3.388	.007	6.776	.027	10.164	.061	13.553	.109
	15	8.663	3.353	.007	6.707	.027	10.060	.061	13.413	.108
	30	17.325	3.318	.007	6.637	.027	9.955	.060	13.273	.107
	45	25.987	3.283	.007	6.567	.026	9.850	.060	13.134	.106
68	00	34.650	3.248	.007	6.497	.026	9.745	.059	12.994	.105
	15	8.664	3.213	.006	6.427	.026	9.640	.059	12.853	.104
	30	17.327	3.178	.006	6.356	.026	9.535	.058	11.713	.103
	45	25.990	3.143	.006	6.286	.025	9.429	.057	12.572	.102
69	00	34.654	3.108	.006	6.215	.025	9.323	.057	12.431	.101
	15	8.665	3.072	.006	6.145	.025	9.217	.056	12.290	.100
	30	17.329	3.037	.006	6.074	.025	9.111	.056	12.148	.099
	45	25.993	3.002	.006	6.003	.024	9.005	.055	12.006	.098
70	00	34.658	2.966	.006	5.932	.024	8.898	.055	11.864	.097

The projection having been laid down, the astronomical observation stations are plotted in their correct latitudes and longitudes, and the points of the main triangulation are plotted in accordance with the results of the computation of that work. The stations of the secondary triangulation and the locations of all boat signals are next plotted with reference to the stations of the main triangulation from the records of the work of the secondary triangulator, and the shore line and adjacent topographic features are delineated from the smooth copies of the shore sketches prepared by the secondary triangulator, having recourse to photographs taken from the ship and from numerous stations, and to the records in which are to be found cuts upon off-lying rocks or islands upon prominent landmarks, upon the mouths of creeks and rivulets, upon the edges of precipices, and the like, and tangents to the shore lines and to topographical features.

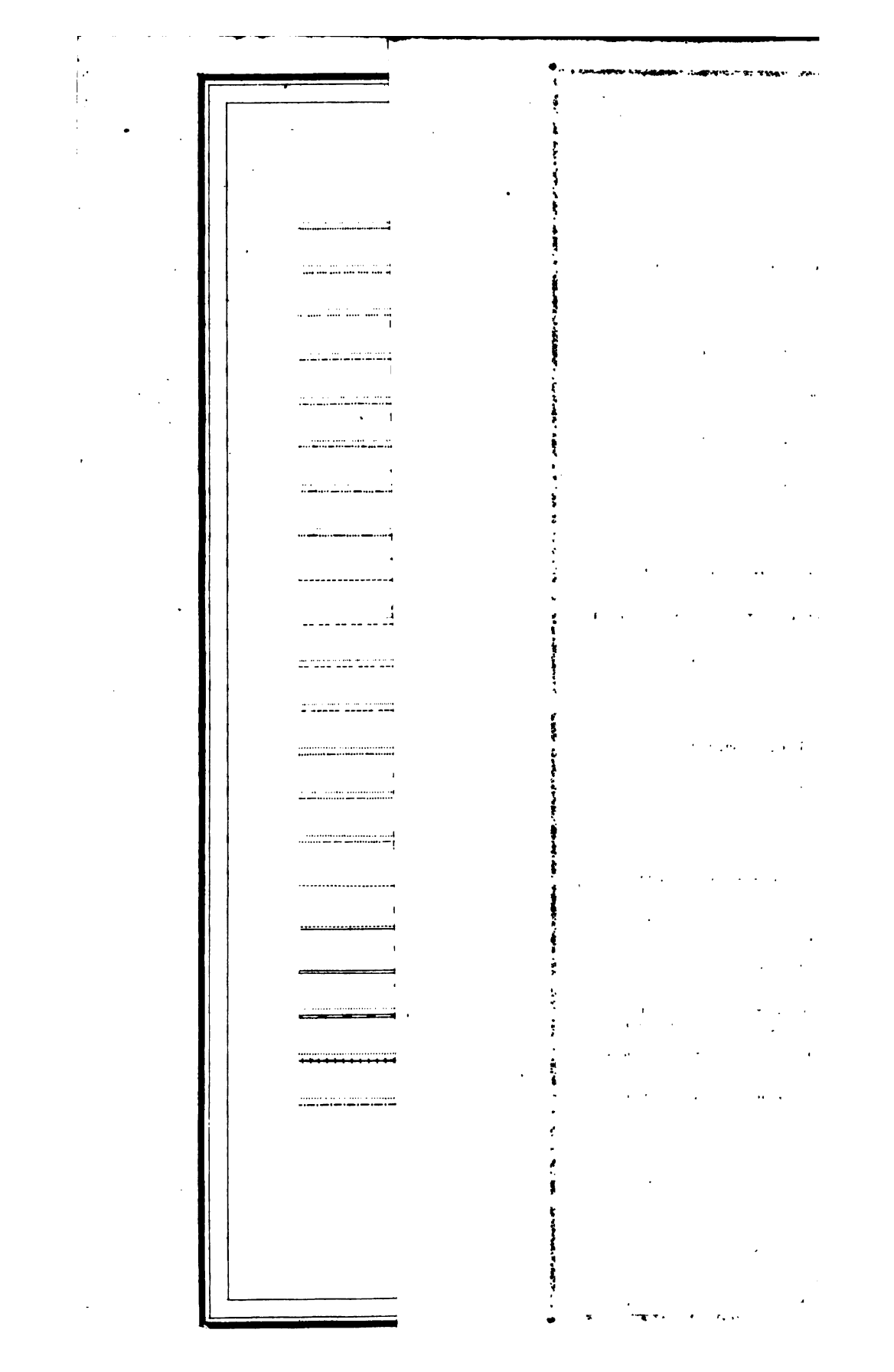
The computed heights of the prominent objects are now entered upon the sheet, and the general topographical features of the region traversed by the main triangulation are delineated from photographs taken from the different peaks, from the ship, and from the shore stations, and from the sketches and recorded observations of the main triangulator. In this manner contour lines at intervals of 100 feet of vertical elevation can be drawn to represent with a fair degree of approximation the relative heights, shapes, and positions of the topographical features.

Using for guidance the deck board and boat sheets, upon which the soundings are roughly laid down, the hydrographic work is next plotted from the records in the ship's and boats' sounding books in which soundings have been reduced by means of the tidal observations to the plane of mean low water, and the 1, 2, 3, 5, 10, 50, and 100 fathom lines are drawn.

All parts of the work having been carefully inked in a legend is added to the sheet, stating the region which it represents, as "San Bartolomé Bay to Abreojos Point," the date of the survey, and the names of those employed in it, the geographical positions of the observation stations, the information concerning tides, and the conventional signs and abbreviations which have been used in charting the work.

Special plans of harbors and anchorages are plotted on separate sheets on enlarged scales depending upon the intricacy of channels and the amount of detail which it is desirable to show. The special plans of Asuncion and Abreojos anchorages occurring in last season's work were plotted on a scale of 4 inches to the nautical mile. It is customary to prepare these sheets of special localities first and then transfer the work upon them to the general sheet by dividing them and the regions covered by them on the general sheet into small squares or rectangles by series of corresponding parallels of latitude and meridians of longitude and then drawing by the eye in each square of the general sheet what occurs in the corresponding square of the special sheet.

These plotting sheets are then drawn for engraving upon the scale on which they are to be published. For the projection of nautical



charts embracing an extent in which the curvature of the earth is appreciable, the Mercator projection is used. For charts of harbors and special localities, covering a small extent over which the surface of the earth is sensibly flat, simple plans are used. The Mercator projection, which is used exclusively by all the hydrographic offices of the world, results from the development upon a plane of a cylinder, tangent to the terrestrial spheroid along the equator, upon which the parallels of latitude and meridians of longitude have been projected in such a manner that a loxodromic curve, or the track of a ship when the course is invariable, shall appear upon the development as a straight line.

The principles of the projection are such that any straight line on the chart represents the projection of some loxodromic curve, and shows a particular mutual bearing of the two places which are connected by it. So that in pursuing a straight line on this projection the course is invariable though the route is really circuitous. The simplicity of the methods necessary for navigating this circuitous track, and the long duration of its usage have so intrenched it in the estimation of mariners that no methods of handling charts not analogous to these find favor with them.

The first step in drawing the chart for engraving is to lay down the projection on drawing paper according to a computation, of which the following is a specimen:

Computation of the projection for the special coast chart from Cerros Island to Abreojos Point.

Scale of construction: $\frac{1}{4}$ inch = 0.63499 c. m. = 1′ of latitude in 27° 27′ 40″ N.

Subtracting the meridional parts for 27° 27′ from those for 27° 28′, as taken from the table, we have 1′ latitude = 1′.121 of longitude, therefore 1′ longitude = $\frac{0.63499}{1.121}$ = 0.56645 c. m.

Lowest parallel, 26° 30′ N., Eastern meridian, 113° 10′ W.. whole extent in latitude, 73.023 c. m.
Highest parallel, 28° 25′ N., Western meridian, 116° 00′ W., whole extent in longitude, 96.296 c. m.

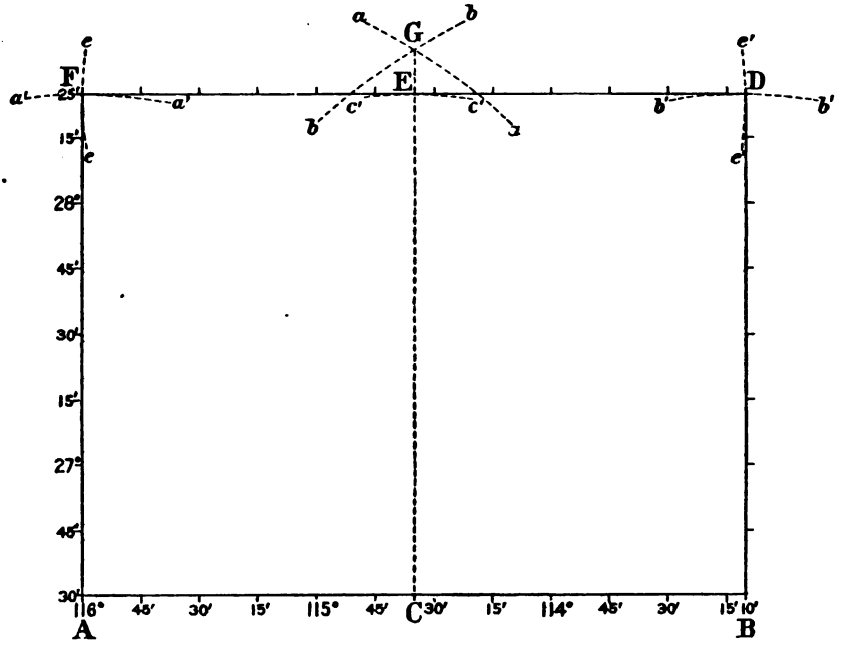
Latitude.	Meridional parts.	Meridional difference.	Multiplier.	Distance from lowest parallel.	Distance from highest parallel.	d_1	d_2
° ′				*c. m.*	*c. m.*		
26 30	1639.481	0.000	0.56645	0.000	73.023		.....
						9.454	
45	1656.170	16.689	.....	9.454	63.569		0.019
						9.473	
27 00	1672.894	33.413	.....	18.927	54.096		0.022
						9.495	
15	1689.657	50.176	.....	28.422	44.601		0.022
						9.517	
30	1706.458	66.977	.....	37.939	35.084		0.022
						9.539	
45	1723.297	83.816	.....	47.478	25.545		0.022
						9.561	
28 00	1740.176	100.695	.....	57.039	15.984		0.021
						9.582	
15	1757.093	117.612	.....	66.621	6.402		.....
						6.402	
25	1768.395	128.914	.....	73.023	0.000	.....	.....

1′ of longitude = 0.566 c. m. 30′ of longitude = 16.993 c. m.
15′ of longitude = 8.479 c. m. 1° = 60′ of longitude = 33.987 c. m.

Lay down the line A B equal to 96.296 centimeters, the whole extent in longitude, and mark its middle point at C. From A and B as centers, with an arbitrary radius, describe the arcs *a a* and *b b* intersecting in G, and connect the points C and G by a straight line.

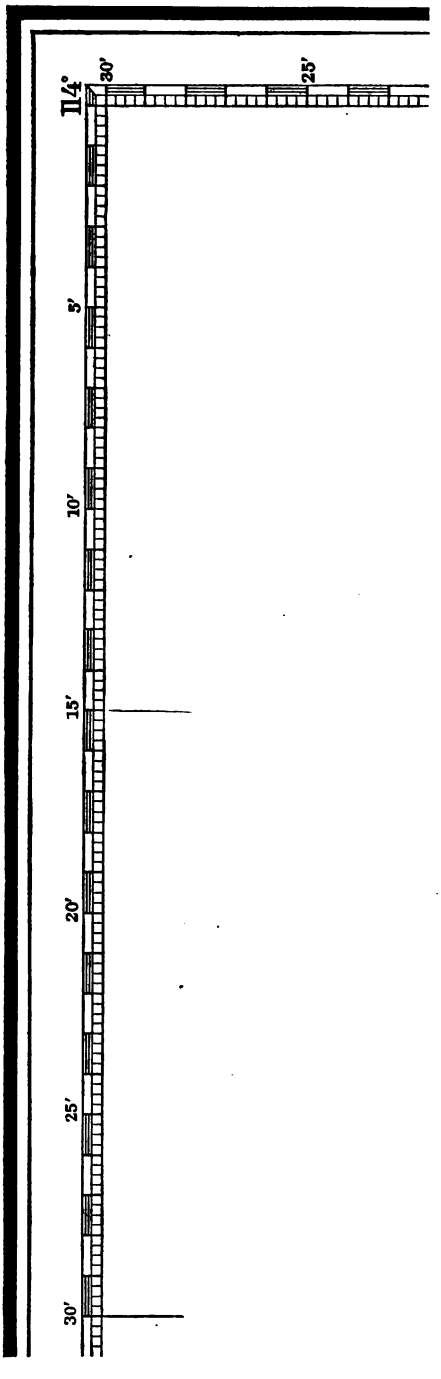
From A, B, and C as centers, with a radius equal to 73.023 centimeters, which is the whole extent in latitude, describe arcs *a' a'*, *b' b'*, and *c' c'*. From the point E, which is the intersection of the arc *c' c'* and the straight line C G, as a center, describe the arcs *e e* and *e' e'*, cutting the arcs *a' a'* and *b' b'* at F and D.

The figure A B D F should be tested for rectangularity by observing the equality of the lengths A D and B F.



From the points A and B on the extreme meridians A F and B D lay off the distances given in the fifth column of the computation, and from the points F and D lay off the distances in the sixth column. The method of double measurement will insure accuracy in locating the points of intersection of the parallels of latitude with the extreme meridians. Between the points thus found the latitude scale can be subdivided into equal parts without appreciable error, as it appears from an inspection of the second differences in the eighth column that the difference between the successive lengths established on the latitude scale is uniformly 0.02 of a centimeter. The intersections of the meridians with the extreme parallels A B and D F are found in the same manner from the table of longitude intervals.

After the projection is laid down, the latitude and longitude scales are subdivided, as shown in the accompanying diagram, and a network



of parallels of latitude and meridians of longitudes, one-fourth of a minute apart for a special coast chart on a scale of one-fourth of an inch to the minute of middle latitude, is drawn over the entire sheet in light pencil lines. A network of corresponding parallels and meridians is then drawn on the plotting sheet to be reduced. A large number of small rectangles correspondingly placed is thus formed on each sheet. The parts within given rectangles on the plotting sheet are now transferred by the eye to the corresponding rectangles of the new drawing. Not all the soundings which have been taken by the surveyors need be entered upon the drawing. Indeed, it is customary, for the sake of clearness, to exclude a large percentage, yet enough are retained to show by their fullness and sequence the depth of water at every step. It is the aim to include all information of a nature to aid the mariner in navigating his ship, such as the appearance of the shore, whether high cliff, low rock, flat beach, marsh, or mud bank; its general elevation; whether it is barren or cultivated; convenient landing places; the materials of the beach, whether sand, gravel, shells, shingle, or stones; the condition of the shore with respect to surf and breakers; the places where water, wood, or coal can be procured; and the mountains and hills which can be seen from the offing with their heights expressed in figures, and with whatever conspicuous objects stand upon their sea faces. In the preparation of drawings for engraving that refinement and excellence of execution which should characterize drawings for photolithographing is not necessary; accuracy and clearness are the essential conditions, so that the engraver may readily transfer all parts to the proper positions on the plate and distinctly recognize what is meant by every character. The drawing, having been inked in, is revised and finally corrected and cleaned by the draftsman.

THE ENGRAVING.

The drawing is then given to the engraver, together with a plate of polished copper, free from all impurities and discolorations, upon which the projection has been laid down according to the original computation. It is found necessary in engraving charts to effect a division of labor, as individual engravers rarely excel in engraving both topography and letters. The plate first goes to an engraver of topography, who proceeds to trace the outlines of small portions at a time of the coast line of the drawing upon transparent gelatine or zylonite by means of a sharp, steel point. The scores produced upon the gelatine in tracing are filled with powdered graphite, and the tracing is inverted and placed upon the plate, which has previously been covered with a solution of beeswax in alcohol, which leaves a thin layer of the former. The proper location is determined by the coincidence of the parallels and meridians of the tracing and the plate. The tracing is then rubbed on the back with a steel burnisher and the graphite is forced out upon the

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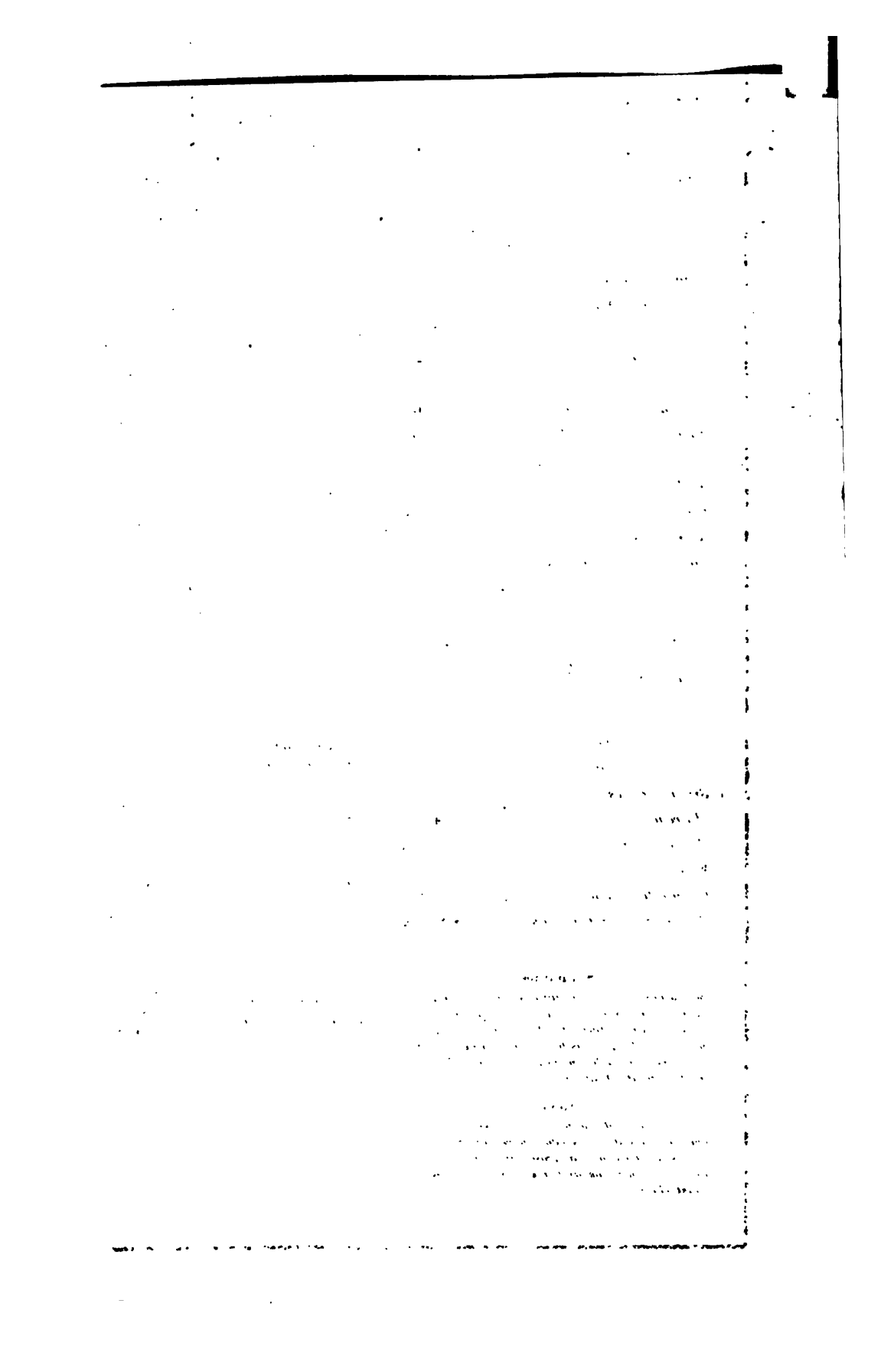

layer of beeswax and shows all those parts which have been traced. The parts thus laid down upon the plate are then engraved, and so each portion of the drawing is traced, laid down, and engraved in succession. The plate, tracings, and drawings are now given to an engraver of letters and figures, who traces his portion of the work upon the same pieces of gelatine as were formerly used to trace the outlines, and lays it down upon the plate as previously described. He then gauges the letters and figures by means of standard gauges, marks them in, and engraves them; after which the engraver of topography proceeds to engrave the details of the topography, such as sand areas, fathom and danger lines, bluffs, areas of swamp and marsh land, and contour lines. The mountains and hills are shaded by means of a hand roulette consisting of a small roller of hard steel, having two or more circumferential rows of spurs upon its surface, mounted upon the end of a curved handle. This, being rolled over the plate, produces series of indentations upon it, the depths and sizes of which are varied according to the pressure applied. The projection lines and border having been engraved as well as all other portions of the chart, the entire land surface of the chart is tinted by drawing over that portion of the surface of the plate a slide, arranged upon a suitable track, in which is mounted a small wheel with a serrated circumference called a roulette. The roulette holder is capable of receiving a transverse feed, so that a series of parallel lines each consisting of a succession of indentations is produced upon the plate.

Proofs of the plate are printed as each stage of the engraving is completed and compared with the drawing to insure correctness of reproduction, and a final revision of all parts of the chart is made, when the engraving is finished.

PRINTING.

In printing a chart, the plate is warmed upon a gas furnace, entirely covered with printing ink by means of a roller, wiped with bunting or waste to remove the excess of ink, and polished by hand so as to remove the ink from all portions except the graven surfaces. The plate having been laid upon the bed of the printing press, which is a slab of cast iron capable of a longitudinal motion under a heavy cast-iron roller which presses upon it, and covered with a sheet of chart paper which has previously been saturated with water to render it perfectly flexible and capable of lifting the ink out of the graven surfaces, is passed through under heavy pressure, and thus yields a copy of the engraving. Felt blankets are used between the pressure roller and the paper and plate to secure a more uniform pressure and to absorb the water which is pressed out of the saturated paper. This process must be performed for each copy like the accompanying one. After printing, the charts are laid out on racks to dry and are finally subjected to heavy pressure to flatten the surface which becomes warped in drying.

JAN 6 1911